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PAPERS AND PROCEEDINGS

OF

The Royal Society of Tasmania

VOLUME 108

NATIONAL MUSEUM
- 5 DEC 1974
OF VICTORIA

Edited by an Editorial Committee

PUBLISHED BY THE SOCIETY

Hobart, Tasmania

2 September 1974

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA
VOLUME 108

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ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT FOR THE YEAR 1973

The Council has the honour to present to members the following report on the activities of the Society during the year.

Annual Meeting

At the Annual Meeting on 6 March, Mr. M.R. Banks retired as Vice-President, and Dr. D. Martin and Mr. A.R. Neilson as Members of the Council. The following were elected

Vice-President	-	Dr. W. Bryden
Members of Council	-	Mr. M.R. Banks Mr. M.H. Bennett
Honorary Secretary	-	Mr. D.R. Gregg
Honorary Treasurer	-	Mr. G.E.A. Hale
Honorary Auditor	-	Mr. A.M.D. Hewer

Lectures

The following lectures were given in Hobart during the year:-

March - "Charles Gould - First Government Geologist of Tasmania" by Mr. M.R. Banks, Retiring Vice-President.

April - "Tasmanian Science and Scientists in the 1840s" Clive Lord Memorial Lecture by Dr. W. Bryden.

May - "Recent Trends in Educational Research" by Professor R. Selby Smith, University of Tasmania.

June - "Fishing in Greenland" by Mr. D.G. James, C.S.I.R.O., Hobart.

July - "Was Macquarie Island under Ice?" by Dr. E.A. Colhoun, University of Tasmania.

August - "Changing Concepts of Cancer" by Dr. J.N. Lickiss, University of Tasmania.

September - "The Endless, Boundless, Stable Universe - the new intellectual conception of the cosmos" by Dr. Grote Reber, Honorary Research Scientist, C.S.I.R.O., Hobart.

October - "Tasmanian Biogeography - with particular reference to freshwater crustaceans" by Dr. W.D. Williams, Monash University.

November - "The Aquatic Eco-System of Tasmania" by Dr. P.A. Tyler, University of Tasmania.

In addition, members visited the Risdon plant of the Electrolytic Zinc Co. of Australasia Ltd. on Saturday morning, 24 March.

Central Plateau Symposium

The proceedings of the Symposium, held at Poatina, 11-12 November, 1972, together with some invited contributions, were published under the title "The Lake Country of Tasmania" in July 1973. The Council is grateful to Mr. M.R. Banks who edited the proceedings and was largely responsible for organising the Symposium.

Resources of the Sea Symposium

A Symposium with this title is planned for Bicheno, 2-4 November, 1974.

Northern Branch

The Northern Branch of the Society based in Launceston had another successful year with several excursions as well as the monthly lectures.

March - "Psyllidae (Lerp Insects)" by Dr. K.L. Taylor, C.S.I.R.O., Hobart.

April - "A View of Psychiatry" by Dr. E.V.R. Ratcliff.

"Discovering Tasmania" by Professor Manning Clark in conjunction with Tasmanian Historical Research Association.

May - "Beach Community in Bass Strait in 19th Century" by Dr. Murray Smith in conjunction with Tasmanian Historical Research Association.

June - "Special Collections and Archives" by Mr. G.T. Stilwell, Librarian Special Collections, State Library of Tasmania, and President, Tasmanian Historical Research Association.

July - "Railways of the West Coast with Emphasis on Zeehan" by Mr. L.S. Whitham, Hobart.

August - "Early Man in Tasmania - His Place in Human Evolution" by Dr. A. Wallace, University of Tasmania.

September - "Museums - What are they for?" by Mr. D.R. Gregg, Tasmanian Museum.

October - Special Meeting - "Tasmanian Biogeography with particular reference to Freshwater Crustaceans" by Dr. W.D. Williams, Monash University.

"What, if anything, is an Echidna" by Professor G.B. Sharman, Macquarie University.

November - "Science and Some Scientists of the 1840s" by Dr. W. Bryden, Vice-President of the Royal Society of Tasmania.

December - Members' Night - "Newstead House" by June Williams

"Selecting the Elite" by H.W. Askeland

"A Matter of Words" by G.H. Stancombe

"Lake Pedder....Lost and Found" by J.N. Gee

"Some Occasions" by K.E.J. Robinson.

Excursions were made to the Westbury district guided by Mr. E.O.G. Scott, and to the Thomas Country, guided by Mr. Harold Thomas of North Down.

On the 17 November the Branch held a successful symposium on "The Forest Wealth of Tasmania". Lectures given were -

"The Tasmanian Forests" by Mr. P.T. Unwin, Chief Commissioner, Forestry Commission.

"The Future of Cellulose" by Dr. M.R. Jacobs, Canberra.

"The Ecology of a Tasmanian Forest" by Dr. J. Kirkpatrick, University of Tasmania.

"Woodchips and Paperpulp" by Mr. I. Swan, Northern Woodchips Pty. Ltd.

"Timber" by Mr. Brendan A. Lyons, Manager, Tasmanian Timber Association.

"The Human Value" by Dr. D.A. Hutchinson, Launceston Walking Club.

Following the Symposium, there was an excursion to the Tamar forest lands under the guidance of Forestry Commission staff.

Papers and Proceedings

The Council decided in the interest of economy to change the printing method used in production of the Papers and Proceedings from "hot metal" to photo-offset. This involved considerable changes in editing procedures which, together with the size of the volume, delayed preparation and printing of Volume 107 greatly. However, a volume of 292 pages was published in February, 1974. It includes two series of papers on Bass Strait Islands held over from Volume 106. The backlog of papers in hand is now cleared, and Volume 108 is in preparation.

Library

The Library, housed at the University of Tasmania, continued under the supervision of Mr. A. Salter.

Finance

It is pleasing to report that the Society has again been able to carry out its budgeted programme of activities and retain a substantial cash balance at the end of the year. This results mainly from the staffing changes made in 1972. Administrative costs are likely to increase, but at the present we are in a position to carry out the programme budgeted for 1974 without increasing subscription.

Membership

During the year the membership was 547, a decrease of 36.

The membership is made up as follows -

	Northern Branch	Total
Honorary Life Members	-	4
Life Members	10	33
Ordinary Members receiving Papers and Proceedings	95	274
Ordinary Members not receiving Papers and Proceedings	116	212
Associate Members	17	24
	238	547

Council Meetings

The Council met four times during the year. Mr. D. Walter and Mr. K.E.J. Robinson represented the Northern Branch on the Council

Maxwell Herbert Bennett

Mr. Bennett, a member of the Council during the year and a member of the Society since 1942, died suddenly on 30 November 1973 shortly after the conclusion of a meeting of the Council. He was a loyal and enthusiastic member of the Council and only an hour before his death had agreed to his appointment as Assistant Honorary Secretary. He was re-organising the accounting procedures of the Society and his death left this partly completed.

Acknowledgements

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the staff, the Government of Tasmania, the University of Tasmania, the Electrolytic Zinc Co. of Australasia Ltd., the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and co-operation.

Papers and Proceedings of the Royal Society of Tasmania, Volume 108

(ms. received 4.7.1973)

A RECONNAISSANCE SURVEY OF THE GLACIATION OF MACQUARIE ISLAND

Eric A. Colhoun and Albert Goede

Geography Department, University of Tasmania

(with three text figures and thirteen plates)

ABSTRACT

The paper reviews previous ideas on the glaciation of Macquarie Island and gives an account of glacial landforms observed during a brief visit in 1972. The field evidence indicates that Macquarie Island was not completely overridden in an easterly direction by an ice sheet which developed on a broad submarine shelf to the west as advocated by L.R. Blake (in Mawson 1943). Local plateau, valley and cirque glaciers accumulated in depressions, basins and valleys on the surface of the plateau and at their maximum extent occupied about 40% of the island. A migration of the Antarctic Convergence from 150 - 200 km south of the island to north of the island would depress sea level temperatures by 3-4^{o}C; an amount adequate to account for the modest glaciation of the plateau surface. The majority of plant and animal species probably immigrated prior to the last glaciation, which is of Wisconsin age, and survived in non-glaciated areas of the present island and adjacent shelf to the west.

INTRODUCTION

Different views have been expressed on the glaciation of Macquarie Island by Blake 1911-14 (in Mawson 1943), by Ivanac (1948), and by Gwynn 1949 (in Law and Burstall 1956). Blake considered that snow accumulated and an ice sheet developed on the broad shallow offshore shelf to the west of the island which was exposed by a lowering of world sea level. He envisaged that the horst-like ridge of the present Macquarie Island had been glaciated by an easterly movement of ice across the ridge from an axis of accumulation in the west during the late Pleistocene (see figure 1). Ivanac accepted that Macquarie Island had been almost totally glaciated by an ice sheet but considered that the main overriding ice moved from southwest to northeast and affected the plateau surface down to 125 m (400 feet) above sea level on the east coast. He suggested that this maximum stage of glaciation was succeeded by distinct stages when the ice cover on the ridge was almost continuous with glacier tongues reaching into the sea and finally be a stage of cirque glaciers. Gwynn questioned the theory that the ice sheet must have developed on the exposed shelf to the west or southwest of the present island. He suggested that the northern end of the island was glaciated during the last phase by ice which accumulated on the present plateau surface which forms the 200-300 m high backbone of the 34 km long island. Though it had previously been assumed that Macquarie Island was totally ice covered during the Pleistocene, Gwynn suggested that non-glaciated headlands and areas of shelf exposed by the lowering of sea level probably existed during the Pleistocene and in these non-glaciated areas some, if not many, species of the present flora and fauna could have survived.

In an attempt to assess the degree and pattern of recent glaciation the authors visited Macquarie Island with the Twenty Fifth A.N.A.R.E. Expedition which landed at Buckles Bay on the morning of Sunday, 19th November, 1972. The all too fleeting five and a half days of the changeover period were spent in making a reconnaissance survey of the glacial landforms and deposits in the northern and eastern parts of the island. The authors walked the main plateau track from A.N.A.R.E. Station via Finch Creek and Green Gorge to Lusitania Bay and returned via Green Gorge and Bauer Bay to A.N.A.R.E. Station. Place names used are shown on figure 1 and are those given on Macquarie Island map sheet, scale 1:50,000, First Edition, November 1971. Unnamed mountains are designated by spot heights or the highest enclosed contour.

FIG.1. - Topographic map of Macquarie Island.

Though the main plateau track was generally followed, many minor detours were made to observe specific forms and deposits where features of interest were encountered. Unfortunately, time did not permit an exhaustive survey of the area traversed or a reconnaissance survey of the area south of Lusitania Bay and most of the west coast. The purpose of this report is to present our preliminary findings on parts of the northern and eastern areas of the plateau that forms Macquarie Island, to deduce the degree, pattern and character of the final glaciation and to suggest the main controlling factors. We acknowledge our indebtedness to A.N.A.R.E. for the privilege of the transport and facilities provided during our visit to Macquarie Island and hope that these first results may be succeeded by more detailed investigations on a future occasion. We also acknowledge our appreciation of the University of Tasmania for its support of this research project.

GLACIAL AND NONGLACIAL LANDFORMS

In any attempt to differentiate between areas which have been glaciated and areas which have escaped the effects of glacier ice in close juxtaposition, it is necessary to outline briefly the criteria which have been utilised to infer glaciation and the other criteria which indicate that certain areas may not have been glaciated. Blake (in Mawson 1943) recognised striae, roches moutonnées and many of the deep lakes and tarns as the products of glacial erosion on the plateau surface. He also recognised the presence of till deposits, end moraines and fluvioglacial deposits as the products of deposition by ice and its meltwaters. In addition he noted that many of the shallow lakes occupied hollows in the glacial drift rather than ice scoured rock basins. Ivanac's (1948) notes are extremely brief and add no factual records to the earlier work of Blake. Unfortunately, Gwynn's (1949) ideas are not discussed at length in Law and Burstall (1956) and he does not appear to have published his views on the glaciation of Macquarie Island elsewhere.

During the traverse made by the present authors, the presence of striae, glaciated outcrops, roches moutonnées, cirques, tarns and glacially deepened valleys with lakes was noted and indicated areas where glacial erosion occurred during the last glaciation. Glacial and fluvioglacial deposits include till, occasional perched blocks, glacial boulders and cobbles on the surface, end moraines, recessional and/or readvance moraines, lateral banks of glacial drift, kame terraces, outwash terraces, and those of former proglacial lakes. In addition the glaciated areas have experienced the erosive action of glacial meltwaters which have cut several varieties of meltwater channels deeply into bedrock during the stages of deglaciation. Though these forms and deposits are widespread on the northern and eastern parts of the plateau surface it soon became apparent that their distribution was not ubiquitous, that they occurred together in certain areas and were notably absent from the bare higher summits and ridges of the mountains and from some of the lower hills on the plateau surface. Also, most of the east coast margin to the plateau bears little direct trace of glaciation south of Finch Creek except at the valley and basin outlets where the cliff line is lower as at Red River, Green Gorge, Waterfall Bay, the unnamed basin ease of Mount Martin and Lusitania Bay. It also became apparent that the till cover was discontinuous on the plateau surface and that the distribution of glacial boulders and cobbles was not ubiquitous. Most of the thick deposits of till observed occurred on the floors of the larger valleys and as plugs in the minor valleys of the northeastern coastal slope.

Many of the mountain summits, high ridges and hill crests between the valley floors and the basins in the plateau surface which were occupied by ice show no trace of glacial erosion and lack landforms due to glacial deposition. The complete absence of cobbles and blocks bearing glacial striae or flat-iron faces from the surface of an area can be due to total removal by glacial scour but when the absence is accompanied by an absence of striated and smoothed bedrock surfaces and is further accompanied by the presence of intensely frost shattered crags, periglacial tors, very coarse block screes and block fields the inference is clear that these areas were not glaciated during the last glacial stage.

FIG. 2.- The extent of glacier ice on Macquarie Island during the Last Glaciation.

FIG. 3.- Glacial and fluvioglacial landforms of Macquarie Island.

The widespread development of solifluction deposits which occur mainly in the form of broad terraces and occasionally as lobes on steep slopes, and the presence of stone polygons and stone stripes cannot be used as indicators of non-glaciated areas on Macquarie as the present island lies in a humid periglacial environment and these forms occur in both the formerly glaciated and non-glaciated areas.

EVIDENCE FOR GLACIATION

For convenience the glacial and associated features observed will be described for three sub-regions which are defined as follows.

1. The Northern Plateau being the sub-region north of Stony Creek on the west coast and Finch Creek on the east coast.

2. The North Central Plateau being the sub-region that extends south of 1 to Green Gorge in the east and lies north of Mount Waite in the west.

3. The South Central Plateau being the sub-region that extends south from 2 to Lusitania Bay in the east and lies north of Mount Hamilton in the west. South of 3 the fourth sub-region, the Southern Plateau, was not visited.

The Northern Plateau

On the Northern Plateau clear evidence of glaciation exists between the rock basin lakes developed to the southwest of North Mountain, centred on Scoble Lake, and Island Lake (figure 2). Glacier ice also accumulated in Rookery Creek and moved downslope towards Nuggets Point. Cloud did not permit observation in Nuggets Creek where Blake, recorded a series of till deposits. There is every reason to believe that Nuggets Creek was occupied by ice of similar form to that in Rookery Creek. Ice also developed to the west of Mount Elder and Mount Blair, and north of the unnamed mountain which culminates in the spot height marked 268 m, 1.5 - 2.0 km north of Finch Creek.

The accumulation of a shallow dome of ice on the north western portion of the Northern Plateau is witnessed by the presence of many west-northwesterly oriented rock basin lakes in the area around Scoble Lake. Though some may be partially impounded by glacial deposits the larger lakes occupy rock depressions which are separated by low ridges that exhibit glacial surfaces, roches moutonnees and are sporadically mantled with thin soliflucted till which contains striated and smoothed cobbles and boulders. This ice moved westwards and northwestwards towards the coastal slope and Half Moon Bay and was probably between 50 m and 100 m thick. Owing to thick cloud and rain it was not possible to determine whether this shallow ice dome extended to the northern cliffline but it is suspected from the contrast of the degraded form of the fossil cliffline of the plateau edge north of Island Lake and the sharp steep undegraded cliffline to the plateau edge between the spot height of 241 m and Perseverence Bluff that all the ice moved westnorthwestwards and northwestwards and did not descend the northern slope. The northern margin of the ice dome probably thinned out just short of the northern cliff edge leaving a narrow non-glaciated cliff top strip.

Striated and faceted blocks of basalt and gabbro up to 25 cm in diameter were found in a small pile of rocks by the track on Perseverance Bluff at 200 m height. Despite this find Perseverance Bluff does not appear to have been glaciated during the last glacial stage as the rock pile resembles a small cairn and the blocks could have been carried from the Scoble Lake area by persons returning to A.N.A.R.E. Station from either Bauer Bay or Sandy Bay huts. No other evidence for ice was found on the crest of Perseverance Bluff though one small crescent-shaped ridge lying on a shelf to the southeast at about 130 m and tucked close into the base of the eastern slope resembled a protalus rampart form about the periphery of a snowpatch hollow (figure 3). Another small crescent-shaped ridge near the head of the gully to the south looked like a small moraine that bounded a small glacieret formed in the gully head. Closer inspection would be required to confirm the origin of these ridges.

The eastern margin of the ice dome did not cover North Mountain but thinned out against the western slope at about 250 m. Above this level large screes with joint determined blocks of 0.3 - 0.6 m diameter mantle the slope and appear to be stable under the present humid periglacial conditions. The rock outcrops on the summit ridge of North Mountain have been sculptured by intense and enduring frost weathering into summit crags and periglacial tors (plate 1). The dolerite of the scree blocks and tors is presently undergoing granular disintegration by the combined effects of chemical weathering and frost loosening of the particles. No till, glacial cobbles and boulders, or ice abraded rock surfaces, were encountered on the mountain and the sharp eastern cliff edge could not have been overrun by glacier ice or it would have been degraded by ice erosion. Snow which fell on the mountain would have been blown by westerly winds over this sharp edge and could have accumulated in the depression between North Mountain and Halfway Hill. The sharp eastern edge of North Mountain in probably a cirque headwall but low cloud precluded viewing this wall and the basin below. The gabbro rock and talus of North Mountain are presently being reduced in size to screes with particles of less than 20 cm diameter and granules by the combined effects of moderate frost shattering and chemical weathering of the surfaces. The large joint determined block screes are not being added to but are being reduced by these processes.

PLATE 1.- Small arcuate moraine ridge between Boot Hill and the southern spur of North Mountain. Note small tors on the summit of North Mountain and the sharp edge to the eastern plateau slope.

To the southwest and south of North Mountain ice from the Scoble Lake area extended as a glacier tongue between Boot Hill and North Mountain and may possibly have passed over the scarp edge into the head of Nuggets Creek (plate 1). A small moraine ridge 5-8 m high occurs on the margin of a shallow rock basin at 210-220 m height east of Boot Hill. This moraine may mark the limit of the ice tongue shown on figure 2 or a stage in the retreat of ice from Nuggets Creek.

South of Boot Hill and north of spot height 308 m the extent of glaciation was not clearly determined. Most of the area appears to have been ice free except perhaps for a northwesterly ice flow from the glacial lake area west of Mount Elder towards Island Lake. Island Lake occupies a shallow rock basin and was certainly glaciated by ice which originated in the hill basin to the southeast. The ice flowed northwestwards across the lake basin. Small tors on the ridge to the northeast and on the ridge to the northwest that culminates in spot height 241 m indicate that the thin ice probably did not merge with the shallow ice cap of Scoble Lake but was confined within the lake basin. Small amounts of meltwater may have flowed northwards through the low col between the ridges towards the cliff line but ice does not appear to have flowed through this col nor does it appear to have been thick enough to have surmounted the western edge of the lake basin as far as the plateau edge. Several stages of glacial retreat or readvance are depicted by the small latero-terminal moraine ridges composed chiefly of fluvioglacially washed sands and small gravels that occur on either side of the lake. Two moraine ridges were observed on the northern shore of the lake to the northwest of the sand bar. Three occur on the western shore of the lake and north of the sand bar.

The curvature of these moraines was controlled by the form of the Island Lake depression which must have been present prior to the last ice movement into the basin. Southeast of the sand bar more morainic hummocks were observed and were formed during the south-westward retreat of this ice lobe.

Blake noted that Rookery Creek had been glaciated and recorded till, outwash and end moraine deposits down to within 30 m above sea level at Nuggets Point. Our observations confirm that Rookery Creek was glaciated and from the top of the sharp headwall about six arcuate morainic ridges were seen to span the valley floor from about 200 m down to at least 50 m above sea level (plate 2). The highest ridge at about 200 m elevation appeared to be a coarse block moraine that was tucked in against the north-eastern slope of Mount Elder. The next three ridges below this at about 150m, 120m and 100 m respectively appeared to be mainly composed of blocks. The lowest moraines were too distant and vegetated to determine their composition. The sharp bounding headwall is that of a low level cirque basin that has been engraved into the east facing coastal slope. The sharp break of slope in the rock between the plateau surface and the cirque headwall has not recently been overriden by an ice-flow from the west or it would have been degraded and rounded off. The convex terminal curvature of the ice-distal sides of the moraines indicates that during the last glacial stage the ice developed within the amphitheatre-shaped valley of Rookery Creek and that the moraine ridges represent retreat/readvance stages during the general south-westward retreat of the cirque glacier. The plateau surface marked by spot height 321m to the west and Mount Elder to the south appears to have been ice free. Fresh screes occur on Mount Elder and on the headwall of Rookery Creek cirque.

PLATE 2.- Moraines on the northeastern coastal slope below the cirque of Rookery Creek.

Blake recorded erratics of enstatite-peridotite near sea level on the east coast at Nuggets Point and suggested that a train of these erratics extended across the island from Eagle Point in the west to Nuggets Point on the east and that this train of erratics indicated an easterly flow of the ice sheet. Recent mapping by Varne and Rubenach (1972), shows that in addition to the Eagle Point outcrop there are five other surface outcrops of serpentinised peridotite to the east of Island Lake from which the surface glacial cobbles could have been derived. Thus the geological evidence need not necessarily be interpreted as indicating an easterly ice flow across the island.

West of Mount Elder and east of the hill marked by spot height 308m is a group of nine small lakes. Several of the larger lakes lie in shallow rock basins. A shallow mass of ice, probably not more than 50m thick, accumulated in this small basin between the two hills. A tongue of ice may have flowed from the basin west-northwestwards towards Inland Lake, but the main flow pattern appears to have been from the lake basin at the foot of the western slope of Mount Elder by a semi-circular route to pass south-eastwards through the col between Mount Blair and the unnamed hill to the west enclosed by the 300 m contour. A small moraine ridge spans the valley at 220-230 m height south of Mount Blair and possibly indicates the limit attained by the ice tongue which flowed through the col.

In the southeastern part of the Northern Plateau another small basin occurs east of the hill marked by spot height 318 m, north of the hill which culminates in spot height 268 m, and the eastern margin of the plateau. In this basin are four small lakes which are aligned along the axis of the shallow glacial trough that curves northwestwards from its source under the northern slope of the hill of 268 m height and terminates just above the plateau edge. The cirque glacier that developed in the south flowed as a glacier tongue along the rock scoured trough that contains the southern three lakes and terminated in a low moraine ridge which dams the most northerly lake and raised its water level slightly above that of the second lake. Another small arcuate moraine separates the second and third lake (not shown on the map). The convex curvature of the ice-distal slopes of these two moraines confirms the north-northwesterly ice flow.

No conclusive evidence was found for the development of glacier ice in the southwesterm part of the Northern Plateau to the south of Island Lake and west of the ridge marked by spot heights 318 m, 277 m and 236 m through a small lake perched in a shallow rock basin at 160-170 m above the western cliffs a kilometre northeast of Bauer Bay may occupy the site of a former perched cirque glacier. Heavy screes on the plateau margin southeast of Bauer Bay are stable and individual blocks have been grooved and polished by the wind. As on North Mountain it is thought that these screes were produced in an extraglacial area during the last cold stage.

The North Central Plateau

The glacier ice which affected Finch Creek valley moved northeastwards from the Square Lake and Tulloch Lake areas and passed seaward of the present coastline through the first major breach in the eastern plateau margin at Finch Creek and Sandy Bay. In the middle part of Finch Creek valley bedrock lies very close to the stream on the northern side but on the southern side thick surficial deposits occur in the deep postglacial V-shaped incision cut by the stream in the valley floor. At one locality above the moraine ridge on the southern side of the valley floor a section shows 1-2 m of soliflucted till resting directly on 4 m of till that overlies bedrock. The small moraine ridge is 5-7 m high and curves across the south side of the valley floor just southwest of the junction of Finch Creek and its lowest northern tributary. Down valley from this moraine the valley mouth is occupied by a broad terrace which despite the thick peat on its surface appears to decline seaward in the form of an outwash terrace developed when the ice stood at the moraine. On the northern side of the valley a ridge occurs beyond the margin of theterrace at a height of 50 m and may be the lateral moraine of the ice which extended seawards of the present coast. This suggests that at least two stages occurred during the retreat of ice from Finch Creek.

Near the mouth of Finch Creek the stream has cut down to expose 7-10 m of poorly to moderately sorted coarse sands and subangular gravels the bedding and morphometry of which is consistent with an interpretation of glacial outwash. The gravels are iron cemented near their base and contain rolled bones. The outwash deposits in turn rest on till and at the valley mouth on more than 1 m of laminated silts and fine sands which appear to be a proglacial meltwater deposit that accumulated in a shallow depression in the till surface. Basalt occurs in the stream bed.

Blake (in Mawson 1943) and Gill (in McEvey and Vestjens 1973) have indicated that three cycles of sedimentation were involved in the development of this valley mouth terrace deposit. Gill suggests that the deposits are not glacial outwash as suggested by Blake and on the basis of one ^{14}C date of 6,000 $\pm$ 120 yrs. B.P. (Gak-643) on Royal Penguin bones from a horizon 6 m above the creek mouth at sea level he concluded that the deposits are postglacial in age. Unfortunately we did not have time to investigate the stratigraphy of this site thoroughly. We consider that much of the deposit is probably of fluvioglacial origin and of late glacial age though some of the higher horizons may be of postglacial age. We also consider that caution is necessary in accepting the date of 6,000 $\pm$ 120 B.P. for the age of the Royal Penguin bones as the gravels are porous, are overlain by thick peat and contamination of this very brittle

bone material is quite possible. Like Gill, we think that it would be worthwhile to date a series of bone samples from different levels within this valley mouth terrace and to make a full stratigraphic record of the site. Until this is done the origin and age of the deposits must remain problematic.

That the ice passed seawards is recorded by two occurrences of glacial striae engraved on a polished surface of basalt that crops out 50 m north of the mouth of Finch Creek. The striae are oriented towards 67° and 72°. Similar striae occur on ice polished basalt on the northern side of the first stream north of Finch Creek and are oriented towards 80°. These striations indicate a flow along Finch Creek from west-southwest to east-northeast.

Glacier ice accumulated in the basin of Square Lake and flowed northeastwards into the valley of Finch Creek. The ice did not surmount the hill to the north marked by spot height 210 m as frost shattering has developed small tors on its crest and there is no trace of glacial smoothing above 170 m. At this level a distinct meltwater channel system has been developed cutting deeply into the rock of the southeastern spur (plate 3). As the meltwater channel approaches the southern tributaries of Finch Creek it bifurcates into several branches and is developed at several levels. Between the channel segments the rock outcrops have a water-washed and eroded appearance. The meltwater system was developed as the ice of Finch Creek withdrew to Square Lake during the deglaciation. A small moraine by the southeastern shore of Square Lake indicates that the ice retreat continued southwards towards Tulloch Lake. The hill marked 207m to the southwest of Square Lake was probably not glaciated and no direct evidence for the glaciation of Stony Creek was found. Thus the ice which occupied the col basin of Square Lake flowed northeastwards but does not appear to have flowed northwestwards.

PLATE 3. - Meltwater channel cut into rock at about 170 m height northeast of Square Lake.

The ice that flowed from Tulloch Lake northeast to Sandy Bay did not override Mount Tulloch or its northern spur marked by spot height 265 m. Mount Tulloch and the spur are crowned by tors and mantled with frost shattered rock. The ice does not appear to have more than half filled the valley that lies north of Mount Tulloch and did not rise above the 250 m contour. Thus at any point the ice was less than 100 m thick. During the retreat towards Tulloch Lake two cross-valley moraines were formed in the valley west of hill 265 m and a third small deposit occurs close to the foot of the northern slope of Mount Tulloch. It is probably a third moraine stage in the glacial retreat but could possibly be a late stage protalus rampart.

Tulloch Lake appears to be deep by comparison with Island Lake and Square Lake and has probably been considerably deepened by ice erosion. At its northeastern end a small hummocky area of moraine separates three small ponds from the main lake, while at its southern end thick moraine overlying rock perches the lake above the deep rock outlet that extends from Little Prion Lake to the head of the Flat Creek valley.

Little Prion Lake occupies a depression in the narrow rock trench that leads northwards from Prion Lake. This trench is the combined product of ice and meltwater erosion.

Just northeast of the outlet of Little Prion Lake a small ridge appears to be a moraine and represents a stage in the southward retreat of the ice flow. North of this a 20-25 m deep glacial meltwater channel has been cut into glacial deposits and bedrock and is continued westwards to Flat Creek (plate 4). This meltwater channel was probably developed after the ice front retreated from Tulloch Lake and while the ice tongue still blocked Little Prion Lake.

Prion Lake is a true rock basin formed by ice erosion. It is reported to be 35 m (110 feet) deep near its northern end (McGregor, 1953) and though Blake considered that it had been developed by strong ice plucking of joint planes during a west to east ice flow across the island the present authors consider that it was developed by the northeasterly flow of ice that accumulated within the leeward basin bounded by the high snowfence of Mount Eitel to the southwest, the hill enclosed by the 300 m contour to the west, and that marked by the spot height of 219 m to the northwest. This was also the view expressed by Gwynn. A small lake shore terrace has been formed at the eastern end of Prion Lake. This terrace is about 1 m above the water level and is probably due to the reworking of a morainic bar by wave action under the influence of strong southwesterly winds.

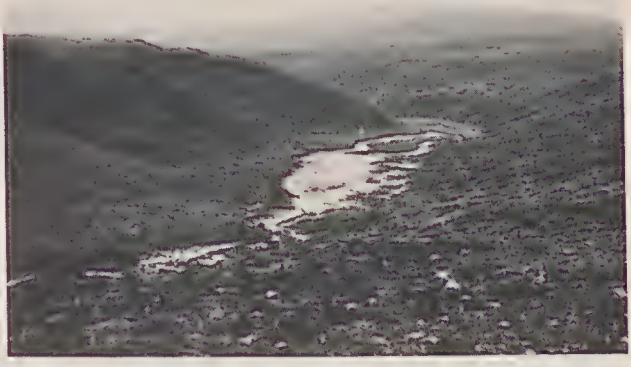

PLATE 4.- Floor of the meltwater channel that drained northwards from Little Prion Lake to Flat Creek.

In addition to the ice that flowed northwards from Prion Lake ice was deflected eastwards by Mount Tulloch towards the plateau margin south of Brothers Point. There are five shallow glacial lakes on the col south of Mount Tulloch and northeast of Prion Lake. A small moraine ridge divides the two in the northwest. Another small lateral moraine ridge occurs at about 200 m height on the southern slope of Mount Tulloch. From the northeastern lake a sinuous meltwater channel descends from about 180-140 m and has been incised deeply into the rock as it flowed eastwards into the northwestern part of a proglacial lake that was developed in a shallow valley above the edge of the plateau. This proglacial lake is now mainly filled with sediment but it appears to have been impounded initially in the northern part of the depression by ice. A moraine ridge occurs on the eastern margin of the lake floor and a small meltwater channel scars the western slope and probably conducted the meltwaters downslope along the ice margin at this stage. As there is no overflow channel cut in any col north of this moraine the lake meltwaters must have escaped subglacially over the plateau edge by the meltwater channel to the southeast of the moraine. After the ice margin had retreated southeastwards from this moraine the proglacial lake was extended southwards and the subglacial meltwater channel changed its function and operated as a lake overflow channel (plate 5).

West of and adjoining this former proglacial lake is a deep rock depression occupied by a lake. The depression has the form of an overridden cirque basin. It is suggested that a discrete low level cirque glacier was formed in it and deepened it early in the glaciation prior to its being overridden by ice from Prion Lake and the valley to the southwest at the maximum extent of glaciation. The ice which flowed northeastwards along this valley did not surmount the elongated hill marked by spot height 249 m but was confined to the west of it. Two stage moraines were deposited against the lower part of the hillslope at approximately 100 m and 150 m respectively as the ice front retreated across the col to the northern part of the Red River basin.

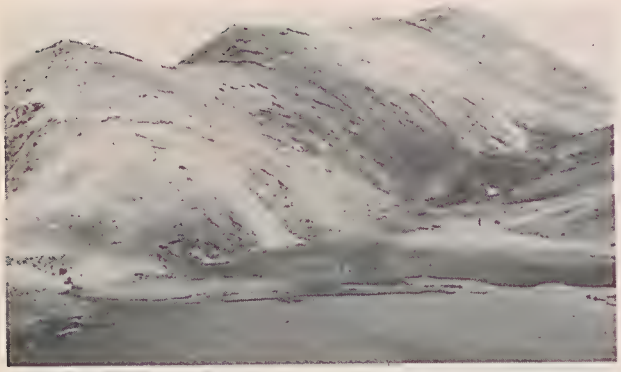

PLATE 5.- Part of the former lake bed 2 km south of Brothers Point showing outlet channel over the plateau edge to the east and two fragments of moraine ridges in the valley to the south.

Glacier ice accumulated under the lee of Mount Ifould and flowed northeastwards through the col between the elongate spur bounded by the 200 m contour east of Prion Lake and the plateau edge hill marked by 249 m, and eastwards at the mouth of the Red River basin. The lakes in the northern part of the Red River basin are mainly shallow lakes caused by an uneven distribution of morainic deposits on the rock floor. Two distinct arcs of moraine are shown on Figure 3 but more detailed observation would reveal considerable glacial deposits in this locality. The lakes on and below the 100 m contour at the confluence of the tributaries are mainly the remnants of a much larger lake which occupied this site and probably originated as a proglacial lake. The exit of the basin was seen to be choked with great thickness of glacial deposits above the plateau edge but detailed observations were not made. To the west the summit of Mount Eitel was probably ice free at the maximum glaciation. South of the former extensive proglacial lake the ice retreated southwestwards into the ice scoured Lake Ifould. Just northwest of the stream which leads from Mount Ifould and southwest of Mount Eitel there is a moraine at 150-160 m from which a meltwater channel drains along the course of the Red River. South of the moraine is a low kame terrace banked against the hillslope and this terrace is seen to originate from the outlet of a meltwater channel that leads across a rock spur to terminate at the moraine (plate 6). These features appear to represent the lateral and terminal forms developed by the ice and its meltwaters during a district retreat/readvance stage in the Red River basin. The chain of lakes to the east was not observed closely but the distinct alignment along a northeasterly curving line that merges with Lake Ifould suggests that the chain was mainly formed by glacial erosion accentuating a line of structural weakness. The mountain marked by spot height 273 m was ice free above 210 m but below this level thick glacial deposits are banked against the northwestern slope. The ice that developed in the cirque basins west of the Green Gorge basin probably just overflowed the col and connected with ice in the Red River basin. The two large cirque basins appear to have been approximately half filled with ice on their inner side and about one third filled with ice near their lips.

The Southern Central Plateau

Glacier ice accumulated in the Greer Gorge basin in large cirque basins which occur on the lower slopes on the western side of the basin in the lee of Mount Ifould and Mount Law. The summits and upper ridges of Mount Ifould and Mount Law were probably ice free at the maximum

PLATE 6.- Low level kame terrace in the western part of the Red River Basin.

glaciation but glacier ice accumulated at several levels in the hollows on the steep leeward slopes. It would appear that here the distribution of ice, snowfields, bare rock ridges and summits was essentially of alpine character with ice and snow in the hollows at all levels on the slopes and that these were separated by sharp ridges which experienced strong frost action while the main glacier occupied the basin below. This ice was confluent with ice which flowed northeastwards along Sawyer Creek and developed at its head in the lee of Pyramid Peak and the two mountains enclosed by the 250 m contour to the west and northwest. The ice in Sawyer Creek and the ice of the Green Gorge basin both extended seawards of the present coastline at Green Gorge. This ice appears not to have exceeded 150 m in thickness inland and was probably about 100 m thick when it crossed the present coast. Though it was probably some of the thickest ice on Macquarie Island during the last glacial stage and caused considerable erosion it still was not thick enough to submerge any part of the crest of the narrow coastal ridge that extends from spot height 276 m east of the head of Sawyer Creek to the area enclosed by the 250 m contour south of Green Gorge which exhibits a few small tors.

At Green Gorge the seaward passage of the ice strongly eroded the rock barrier at the basin mouth and fragmented it into a series of disconnected glacial crags. Behind the crags the floor of a formerly extensive lake is filled with sediment and peat (plate 7). The lake was probably first developed as a proglacial lake during the deglaciation and the distinct cliffs which bound its western and southwestern margin may be spurs truncated by the ice. However, the level of the lake floor is so low (about 12-13 m above H.W.S.T.) that it is just possible that it may have been invaded by the sea passing between the glacial crags at its mouth at the height of the Post Glacial marine transgression. If so, the steep ice truncated cliffs west and southwest of the lake may have been accentuated in places by being retrimmed by wave erosion. Since the lake basin forms a good trap it should contain a very full postglacial sediment sequence.

PLATE 7.- Postglacial lake bed west of Green Gorge showing steep bounding cliffs and low level cirque basins on the slopes of Mount Ifould.

A small meltwater channel occurs on the northern slope leading down to the former lake. Two former parallel submarginal meltwater channels occur between 40 and 100 m height on the northwestern flank of the spur south of Green Gorge (plate 8). These channels are steep V-shaped gorges which are incised 10-12 m into rock, are peat lined, and are either dry or carry underfit streams. A third occurs between 150 m and 100 m height slightly further south. This channel curves obliquely downslope towards the valley axis. The floor of Sawyer Creek is filled with thick glacial deposits that are peat covered. The large moraine ridges span the valley floor at approximately the 100 m contour and slightly north of the junction of the two headwater streams. These two moraines overlie rock and are associated with steep gorge sections of Sawyer Creek which were probably cut by glacial meltwaters during the final deglaciation. These moraines, and a third cross-valley moraine near the head of the eastern headwater tributary, mark stages of retreat/readvance during the general southwestward retreat of ice towards Pyramid Peak.

Glacier ice accumulated in the basin of Jessie Niccol Creek, flowed centripetally towards the centre of the basin and eastwards towards the eastern edge of the plateau between Waterfall Bay and Endeavour Lake.

PLATE 8.- Intake of one of the submarginal meltwater channels on the hillslope southwest of Green Gorge.

The ice was probably between 100m and 150m thick and while it filled most of the basin it did not engulf the surrounding summits. Glacial cobbles and thin morainic deposits occur on the basin floor. The plateau edge spur north of Endeavour Lake marked by spot height 245 m appears to have remained as a nunatak area. Thin ice must have passed northwards via the col north of Pyramid Peak into Sawyer Creek, and, in doing so, eroded the lake basin. Morainic debris occurs around and north of the lake but the summit of Pyramid Peak and the mountain to the west enclosed by the 250 m contour were not submerged and the upper limit of ice action may be represented by a bank of lateral moraine at about 240 m on the southwestern slope. An adjacent hill a short distance west-northwest has a frost shattered summit and exhibits two very coarse block streams on its southeastern slope. The block streams appear to be stable at present. The area above the 300 m contour on the southwest, the high col leading to Major Lake, and Mount Gwynn to the south also appear to have been ice free during the last glacial stage. From the foregoing description it may be concluded that the Jessie Niccol Creek basin operated virtually as an independent collecting ground for snow and ice during the last glacial stage and its only connection with other ice was through the Pyramid Lake col to Sawyer Creek. The accumulation was facilitated by the moderately high snowfence which extends from Mount Blake in the northwest to the mountain in the southwest which culminates in spot height 340 m on the western edge of the plateau.

The platform occupied by Major and Tiobunga lakes to the west of Mount Gwynn and Mount Martin was glaciated by a shallow dome of ice similar to that which developed around Scoble Lake on the Northern Plateau. The Major-Tiobunga lake platform is exposed to the full force of the westerly and northwesterly winds. The shallow form of the ice cap was probably controlled mainly by the topography and partly be the deflation of snow from the ice surface and its transport across the high cols between Mount Hamilton and Mount Martin to the Lusitania Creek basin, between Mount Martin and Mount Gwynn to the basin in the lee of Mount Martin, and northwest of Mount Gwynn to the Jessie Niccol Creek Basin. Almost the entire area of this platform below the 250 m contour was glaciated but there is little trace of glaciation above 280 m except for a small cirque basin on the southwestern slopes of Mount Gwynn which was occupied by ice that merged with the Major Lake ice.

Ice occupied the two small lake basins north of Major Lake and was about 70-80 m thick. In the northern lake basin ice flowed directly westwards to the plateau edge. In the second lake basin ice flowed north-westwards and then westwards to the plateau edge. During the ice recession moraines were deposited on the northern shore of Major Lake. These moraines were not visited but the position of the largest is shown on figure 3. A small peak east of Major Lake and south of the second lake basin remained above the ice surface and has a strongly frost shattered crest. The ice that accumulated on the lower western slopes of Mount Martin flowed northwest into Major Lake and then westward to the plateau edge where it probably terminated in an ice fall. It eroded the rock basin of Major Lake and was probably slightly over 100 m thick. The lakes west and south of Major Lake occur either in ice scoured rock depressions or in hollows in the thick glacial deposits which occur on the shores of and around Major Lake.

Tiobunga Lake was glaciated by ice which developed in the valley between Mount Martin and Mount Hamilton and flowed northwestwards and westwards to the plateau edge. Lack of time and thick cloud prevented further observation in this area.

Glacier ice developed on the floor of the basin to the east of Mount Martin which acted as a snowfence. The summit of Mount Martin was not glaciated and there does not appear to have been any connection between the ice of this basin and that of either Major Lake or Lusitania Creek. A lateral moraine occurs east of the small lake in the southern part of the basin from which the main ice flow was northward towards the centre of the basin and then eastward to the margin of the plateau (plate 9).

PLATE 9.- Lateral moraine and glacial lake basin in the southern part of the basin east of Mount Martin. Note the extensive solifluction terraces.

Mount Hamilton, the mountain to the south enclosed by the 350 m contour and Mount Aurora formed the snowfence which caused the development of glacier ice in the Lusitania Creek basin. This basin appears to have been glaciated by two short glaciers that were developed in the northwestern and southwestern branches of the valley and merged below the spur marked by the 250 m contour in the western part of the basin. The ice did not connect with any other basin and appears to have only half filled the basin probably being slightly more than 100 m thick. The glaciers flowed southeast and northeast before merging to flow eastwards to beyond the present coastline in Lusitania Bay. Three banks of lateral moraine occur between 250 m and 270 m on the southern slope of the hill marked by spot height 304 m (plate 10). These appear to mark the upper lateral limit of glaciation. A similar lateral moraine descends obliquely southeastwards across the eastern spur of Mount Hamilton from about 300 m to 250 m. It is an obvious ice margin limit above which large talus blocks have fallen from the steep eastern slope of the ice free summit of Mount Hamilton.

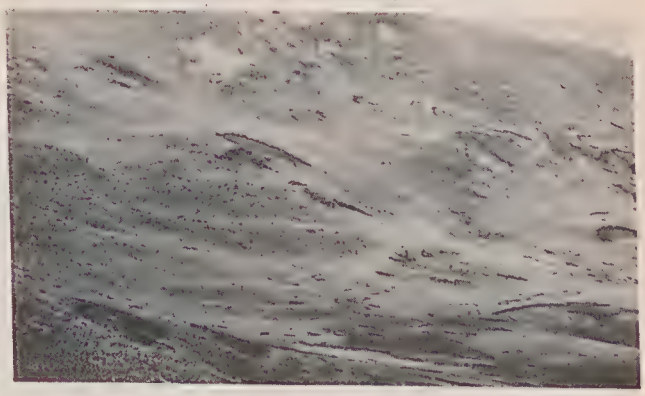

PLATE 10.- Banks of lateral moraine at 250-270 m on the northern side of the Lusitania Creek valley.

A V-shaped meltwater gorge occurs at the mouth of the Lusitania Creek and has been cut 20-30 m deep into the rock of the plateau edge (plate 11). To the south of the gorge entrance there is a small ridge of moraine which indicates a stage in the glacial retreat during which the gorge carried proglacial meltwaters seaward. It is unlikely that such a deep gorge could have been initiated proglacially without the development of a large proglacial lake on the floor of the basin of Lusitania Creek.

PLATE 11. - Meltwater gorge at the mouth of Lusitania Creek valley.

There is no evidence of such a lake and it is probable that the meltwater gorge was initiated subglacially during an earlier stage of the glaciation when the Lusitania ice extended a short distance seaward of the present coastline. Evidence for the development of considerable meltwater in the Lusitania Creek basin is supported by the development of a deep submarginal channel cut into the rock of the hill slope to the south at about 80 m to 100 m (plate 12). This channel trends along the contour before it turns through a right angle to plunge downslope. This suggests that the marginal meltwaters found a subglacial or englacial route to the ice margin stage marked by the moraine at the head of the proglacial meltwater gorge.

The course of the northern tributary stream of Lusitania Creek is inherited from a former meltwater channel the course of which can be clearly seen in the profile between 100 m and 130 m height where a sinuous channel has been incised 15-20 m into the rock (plate 13). The present stream is markedly underfit. Thus the ice retreated southwestwards and northwestwards in the Lusitania Creek basin and the meltwater streams generated during the retreat cut deep rock channels into the basin floor and lower hill slopes.

The Southern Plateau sub-region to the south of Mount Hamilton and Mount Aurora was not visited.

THE PATTERN OF GLACIATION AND DEGLACIATION

Despite the fact that only two thirds of the island was viewed during the changeover period and accepting that an incomplete record was made of the landforms and deposits produced by glaciation within this area, nevertheless sufficient detail was observed to make a preliminary assessment of the extent of ice development, the pattern of ice movements and the nature of the deglaciation (figures 2 and 3).

Though it is possible that Macquarie Island was more extensively glaciated prior to the last glacial stage as suggested by Blake and accepted by Ivanac no record of an older glaciation or glaciation at higher levels was found and the record of the last glacial stage indicates that not more than 40% of the area of the island was glaciated at that time. The development of snowfields and glaciers occurred selectively in the basins and valleys on the eastern side of the plateau to the leeward of the high mountains in the centre of the plateau which acted as barriers to the prevailing northwesterly and westerly winds.

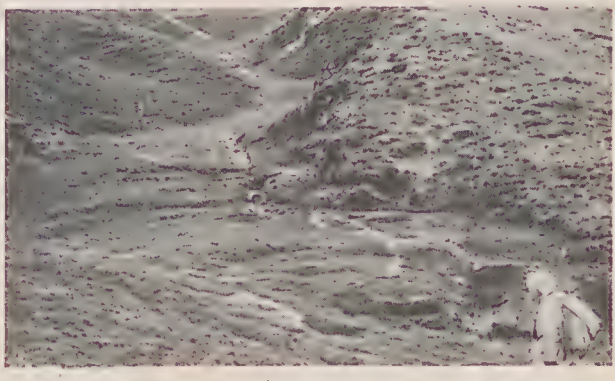

PLATE 12. - Submarginal meltwater channel on the southeastern slope of Lusitania Creek valley showing the abrupt change in direction as the water that flowed along or close to the ice margin turned downslope beneath or into the ice.

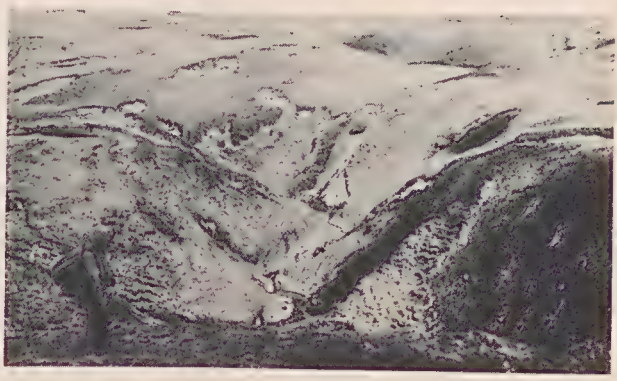

PLATE 13.- Middle section of Lusitania Creek showing present stream occupying a sinuous meltwater gorge.

These snowfences partially protected the snow that was blown over their crests into the eastern basins and valleys from being blows off the plateau into the sea. As the basins occupied by Square Lake, Tulloch Lake, Prion Lake, Ifould Lake and the Red River, Green Gorge and Sawyer Creek, Jessie Niccol Creek, the basin east of Mount Martin and Lusitania Creek, were erosionally fashioned prior to the last glacial stage the flow of the shallow ice masses within them was primarily controlled by the form of the preexisting topography. Where there was a direct easterly outlet at a valley mouth or over the plateau edge as at Lusitania Bay, Waterfall Bay, Green Gorge, Red River and south of Brothers Point the ice flowed eastwards to the sea, but where there was a barrier ridge on the plateau edge as east of Sawyer Creek, Ifould, Prion and Tulloch lakes the ice was deflected northwestwards along the trend of the old valleys before turning seawards at breaks in the plateau margin. Where low cols occurred between adjacent valleys and basins thin ice connected across the cols as at Pyramid Lake, at the col between the Green Gorge and Red River basins, between the latter and the valley leading to the cliff edge two kilometres south of Brothers Point, between Prion Lake and Tulloch Lake, and from Tulloch Lake to Finch Creek. In all cases the ice flowed in a northeasterly or northerly direction across the cols. No ice moved southwards across a col in the eastern part of the island. This pattern does not necessarily imply that most of the snow and hail came from the southwest, but merely reflects the nature of development of the pre-last glacial topography which has a distinct northeasterly erosional trend which is at least partly related to geologic structures. The controlling influence of the pre-last glacial topography on the ice masses was accentuated by the dominance of westerly winds and moist airstreams which when forced to rise over the plateau condensed and fell mainly as snow.

The glacial retreat in each of the eastern basins and valleys occurred in a westerly and southwesterly direction. The cross-valley moraine ridges indicate that several distinct readvance/retreat stages occurred during the general deglaciation. The development of meltwater channels and gorges in and at the exit of several of the basins and valleys indicates that considerable meltwaters were generated during the deglaciation and that processes of fluvioglacial erosion affected the landscape. The absence of such channels from the mountains of the main watershed of the plateau and the eastern coastal ridges indicates that they projected above the ice surface throughout the last glacial stage.

Where the plateau surface is open to the west and is backed by high mountains to the east as at Scoble Lake and Major Lake, shallow ice caps formed from which the ice flowed westwards to the plateau margin. The moraine ridges observed in these areas also indicate that several stages were involved in the easterly retreat of these ice masses during deglaciation.

In the northeast, where basins were not developed inland from the coast, low-level cirque glaciers developed in a perched position on the plateau margin. Such a cirque glacier was certainly developed in Rookery Creek and another was probably developed in Nuggets Creek. To the north a small cirque glacier and large snowpatch may have been developed southeast of Perseverance Bluff. An overridden cirque was developed near the

plateau edge two kilometres south of Brothers Point. The presence of these cirques and snowpatch areas on the plateau edge is primarily due to Perseverance Bluff, North Mountain and Mount Elder being located adjacent to the plateau edge and acting as snowfences which permitted accumulation of snow and ice in the leeward hollows below. The many moraines in Rookery Creek indicate that the ice retreated in several stages westwards toward the cirque headwall.

The development of cirque basins on the eastern slopes of Mount Law and Mount Ifould occurred in a similar way to that of Rookery Creek but their occurrence on the western side of the Green Gorge basin is due to the location of the high snowfences in the centre of the plateau rather than at the coast.

CONCLUSIONS

Blake (1943) and Ivanac (1948) indicated that a total glaciation of Macquarie Island had taken place during the last glacial stage from an ice axis that had developed on exposed sea floor to the west or southwest of the island. Ivanac suggested that this stage of total glaciation was succeeded by later distinct stages when valley glaciers and cirque glaciers were present. The present survey shows conclusively that there was not a total inundation of Macquarie Island by ice during the last glacial stage, that there was not a hypothetical ice axis developed to the west and southwest of the island, and that glacier ice accumulated selectively in basins, valleys, hollows and on broad shelves on the main plateau surface as first surmised by Gwynn (in Law and Burstall, 1956) but demonstrated in more detail here. The locations of the centres of ice development were determined by the combined effects of wind drifting of snow and hail and the pre-last glacial topography of the island. The pattern of the ice movements during the hemicycles of glaciation and deglaciation was controlled by the topography.

There is no reason to believe that distinct consecutive phases of valley and cirque glaciation succeeded the waning of a total ice sheet cover. Small ice caps, valley and cirque glaciers developed synchronously in different locations and at different levels on the plateau surface, on the mountain slopes that rise above the surface and on its northwestern coastal margin. Where one ice mass impinged upon another they became confluent as in the western part of the Green Gorge basin, or the larger ice mass overrode the smaller mass as in the case of the overridden cirque two kilometres south of Brothers Point. Similarly plateau ice caps, basin, valley and cirque glaciers melted contemporaneously and though several distinct retreat/readvance stages can be recognised in each valley the stages do not relate to different morphological forms of ice mass being present at different times.

The conclusion that some 60 percent of the present area of Macquarie Island was not glaciated during the last glaciation is inevitable, not to mention the much greater area which may have been exposed on the shallow shelf to the west of the island during the last major lowering of sea level. This conclusion indicates the strong possibility that most of the endemic and subantarctic species of circumpolar distribution in the flora of Macquarie Island could have arrived prior to the last glacial stage and could have survived the colder conditions in close proximity to their present location. The immigration of all the species by long distance dispersal on migratory birds during postglacial time as advocated by Taylor (1955) need not be substantiated. Similarly penguins albatrosses, skuas, sea elephants and seals probably predate the last glaciation of the island and lived, nested and bred on the non-glaciated portions of the present island and its shelf extensions during the last glaciation.

As Macquarie Island has no glacier ice or perennial snowbanks today the most likely condition that caused the cooling of climate during the last glacial stage would have been a shift of the Antarctic Convergence from its present position 150-200 kilometres south to north of the island. This would have given Macquarie Island a position relative to the Antarctic Convergence similar to that of Heard Island today and would have been sufficient to depress the mean temperature at sea level by 3-4^{o}C. With the present

amount of precipitation of slightly greater than 1000 mm per annum this temperature decrease would have been sufficient to produce the very modest degree of glaciation that occurred on the plateau surface.

There is at present no evidence from Macquarie Island to indicate the age of the last glaciation but there is also no reason to believe that it did not occur synchronously with the last glaciation of Northwestern Europe, North America and the last major advance of ice in Antarctica which latter would have been associated with the northward migration of the Antarctic Convergence. The morphologic character of the glacial landforms and deposits and the freshly incised character of the meltwater channels would also support a Weichselian/Wisconsin age for the glaciation.

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VARIATIONS OF GROWTH RATE OF *EUCALYPTUS DELEGATENSIS* R.T. BAKER SEEDLINGS AT FIVE ELEVATIONS

by Truda M. Howard

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ABSTRACT

Eucalyptus delegatensis R.T. Baker, from a single seed source, was grown at five sites over a range of elevations from 260 m to 600 m on two soil types, in the Surrey Hills district of North West Tasmania. Seedlings were harvested twice, after 26 and 74 weeks of growth. Dry weight and leaf area were measured and at the second harvest the net assimilation rate was calculated for each elevation.

The seedlings at the five elevations formed three significantly different populations, as discriminated on the basis of dry weight and leaf area. The differences in NAR can best be explained by variation in the length of the growing season, and the severity and duration of frosts over the altitudinal range.

The population with the highest NAR (4.16gm sq dm $^{-1}$ week^{-1}) was grown below 300 m, in an area where *Eucalyptus obliqua* is the dominant wet sclerophyll forest species. The population with medium NAR (2.03 gm sq dm $^{-1}$ week $^{-1}$) was grown at three sites between 300 and 600 m, in an area where *E. delegatensis* wet sclerophyll forest is the major vegetation type. The poor growth of the third population (NAR = 0.72 gm sq dm $^{-1}$ week $^{-1}$), grown above 600 m, corresponds to an area in which *E. delegatensis* grassy woodlands, and *Nothofagus cunninghamii* rainforest are the predominant vegetation types.

INTRODUCTION

Eucalyptus delegatensis R.T. Baker is the major eucalypt species in the Surrey Hills District of North West Tasmania (fig. 1) and is being utilised extensively for paper and timber production by Associated Pulp & Paper Mills Pty. Ltd., at Burnie. As part of an investigation into methods of increasing tree productivity and improving regeneration, a study was carried out into the natural optimum growth rates of *E. delegatensis* over a range of elevations within the Surrey Hills forest area of Associated Forest Holdings Pty. Ltd.

Five experimental sites were chosen at elevations of 850 ft, (260m), 1180 (360), 1560 (475) 1780 (540) and 2000 (600m) respectively (fig. 1). The sites lie roughly along a N-S line, and were chosen to have comparable aspects (N) and slopes (less than 2^{o}) and to be free of shade at all times of the day. *E. delegatensis* seedlings were grown from a single local seed source, in the two soil types predominant in the area, one from Devonian granite and the other from Tertiary basalt (table 1).

A number of additional observations were also made on the vegetation types over the altitudinal range and on the growth rates of mature trees and natural regeneration. These observations, combined with rainfall and temperature measurements from each site, were used to interpret the results of the major experiment.

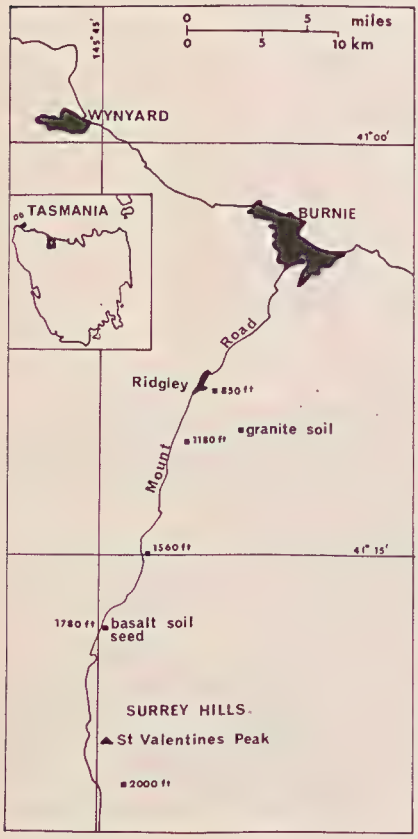

FIG.1. - Map of Surrey Hills District of N.W. Tasmania. (Inset shows location of detailed map). Experimental soil and seed collection sites are shown.

METHOD AND MATERIALS

At each experimental site an excavation of 1.5x6x0.6m deep was prepared. Each excavation was lined with plastic sheeting, and divided into one hundred compartments 0.3x0.3x0.6m deep with black painted hardboard sheeting. Each set of 100 compartments in each block were randomly filled with granitic soil, the remainder with basaltic soil.

The soils used at all five sites came from the same two sources, the basaltic from the top 0.6m of a kraznozem at 540m, and the granitic from the top 0.3m of a yellow podzolic (Stephens 1962) soil at 335m. Some chemical and physical properties of these soils are shown in table 1. Soils were sieved to remove stones and roots. The soil in the compartments was allowed to settle, then topped up to a uniform distance below the tops of the hardboard divisions.

Meteorological stations were set up at each experimental site, and weekly maximum and minimum screen temperatures, together with weekly rainfall measurements were made throughout the experiment. Part way through the experiment, an additional thermometer was installed at each site, at ground level, so that soil surface minima could be measured weekly.

E. delegatensis seed collected in December 1969 from a large number of young trees in a plantation at 535m was used for the experiment. The moistened seed was stratified at 1°C for two weeks prior to broadcasting over all soil compartments at each elevation in the first week of October, 1970. Germination started in the first week of November and by the end of the month, through thinning and transplanting, each compartment contained a single seedling.

An initial harvest of ten seedlings from each soil/site combination was made in the second week of May 1971, and a second harvest of 20 seedlings from each combination in the first week of April 1972. At each harvest, leaf area and seedling oven dry weight were measured.

RESULTS

The means and standard errors for oven dry weight and leaf area at each soil/site combination are given in tables 2 and 3. For seedlings at each elevation, "t" tests were carried out on dry weight and leaf area results to determine whether there were significant differences between plants grown on the two soil types. With one exception (at 475m) in the first harvest) differences in soil type were not reflected by significant differences in either dry weight or leaf area production.

New elevation means were calculated combining results for both soil types, and "t" tests between elevations carried out. The results of these tests are summarised in table 4. At 475m, the difference in both seedling dry weight and leaf area were highly significantly different between soil types, hence each is treated separately in comparisons with other elevations (table 4a).

TABLE 1

Some chemical and physical properties of the two soil types used in the experiment.

Granitic = top 300mm of a yellow podzolic developed on Devonian granite.

Basaltic = top 600mm of a kraznozem developed on Tertiary basalt.

Characteristic	Granitic	Basaltic
pH	4.8	5.0
Sand and Gravel Content		
% Gravel (2mm + in diam)	14	18
% Coarse Sand (2 - 0.2 mm)	58	26
% Fine sand (0.2 - 0.2 mm)	17	12
% Clay and silt (by subtraction)	12	44
Water Stable Soil Aggregates		
% 4mm + in diam	5.8	20.9
% 4mm - 2 mm	14.2	22.1
% 2 - 1.003 mm	26.2	16.5
% 1.003 - 0.500 mm	24.3	10.2
% 0.500 - 0.250 mm	13.6	5.4
pF (wilting point)	4	28
Colour	Grey	Red-brown
P ppm (HCl extractable)	59	741
N % (Kjeldahl)	0.14	0.21
N/P	28.5	4.3

TABLE 2

Seedling dry weight (g) means and standard errors for each soil/elevation combination at each of two harvest times.

First harvest - 26 weeks after germination

Second harvest - 74 weeks after germination

Soil	Granitic		Basaltic	
Elevation mm	1st Harvest	2nd Harvest	1st Harvest	2nd Harvest
260	$7.78^{+2.14}_{-}$	$76.2^{+}_{-13.5}$	$6.81^{+}_{-1.87}$	$94.3^{+}_{-23.0}$
360	$3.25^{+}_{-1.14}$	$50.2^{+}_{-5.1}$	$0.93^{+}_{-0.47}$	$38.0^{+}_{-6.1}$
475	$7.21^{+}_{-2.08}$	$31.9^{+}_{-3.6}$	$1.60^{+}_{-0.43}$	$42.4^{+}_{-6.9}$
540	$2.78^{+}_{-1.13}$	$48.3^{+}_{-5.3}$	$1.20^{+}_{-0.43}$	$38.0^{+}_{-10.2}$
600	$1.10^{+}_{-0.28}$	$17.3^{+}_{-1.7}$	$0.71^{+}_{-0.14}$	$26.0^{+}_{-4.4}$

TABLE 3

Seedling leaf area (sq dm) means and standard errors for each soil/elevation combination at each of two harvest times.

First harvest - 26 weeks after germination

Second harvest - 74 weeks after germination

Soil	Granitic		Basaltic	
Elevation m	1st Harvest	2nd Harvest	1st Harvest	2nd Harvest
260	$^{+4.31}_{-1.15}$	$^{+24.07}_{-4.43}$	$^{+4.17}_{-1.12}$	$^{+30.08}_{-7.44}$
360	$^{+1.84}_{-0.21}$	$^{+15.42}_{-1.51}$	$^{+0.59}_{-0.27}$	$^{+13.44}_{-1.84}$
475	$^{+3.61}_{-0.92}$	$^{+7.47}_{-0.77}$	$^{+1.06}_{-0.29}$	$^{+11.86}_{-1.66}$
540	$^{+1.39}_{-0.41}$	$^{+13.54}_{-1.40}$	$^{+0.76}_{-0.25}$	$^{+11.92}_{-2.87}$
600	$^{+0.70}_{-0.18}$	$^{+5.10}_{-0.44}$	$^{+0.45}_{-0.09}$	$^{+7.70}_{-1.26}$

At the second harvest, the leaf area at 475m was significantly different (5%) between the two soil types; however, as this difference was not observed in the dry weights, the results for granite and basalt soils were combined for the purposes of further testing (table 4b).

TABLE 4A

Results of "t" tests carried out on 26 week old seedlings between sites*. Figures in the body of the table are the probabilities of the difference between sites compared being not significant.

LEAF AREA

Site Elevation m	260	360	475 B	475 G	540	600
260		0.001	0.001	NS	0.001	0.001
360	0.001		NS	0.01	NS	5.0
475 B	0.02	NS		0.02	NS	NS
475 G	NS	0.01	0.01		0.01	0.001
540	0.001	NS	NS	0.01		0.01
600	0.001	0.05	NS	0.001	0.05	

* 475m is treated twice, 475B (basalt sample) 475G (granite sample), because there was a significant difference between growth on the two soils at this site.

TABLE 4B

Results of "t" tests carried out on 74 week old seedlings between sites.

LEAF AREA

Site Elevation m	260	360	475	540	600
260		0.01	0.001	0.001	0.001
360	0.01		NS	NS	0.001
475	0.001	NS		NS	0.01
540	0.001	NS	NS		0.001
600	0.001	0.001	0.001	0.01	

In table 5, the net assimilation rate for each soil/elevation combination is shown. The net assimilation rate was calculated from the following formula:-

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \cdot \frac{\log_e A_2 - \log_e A_1}{A_2 - A_1}$$

where W_2, W_1 = final and initial dry weights (gm)

A_2, A_1 = final and initial leaf areas (sq dm)

$t_2 - t_1$ = duration of experiment (weeks)

In this case, the first harvest was that taken after 26 weeks of growth, the final harvest, that taken after 74 weeks.

TABLE 5

The net assimilation rate (g sq dm $^{-1}$ week $^{-1}$) at each elevation/soil combination between the first (26 weeks) and second (74 weeks) harvests.

Elevation - m	SOIL Granitic	Basaltic
260	3.25	4.20
360	2.25	1.78
475	1.18	1.96
540	2.05	1.77
600	0.78	1.21

Seedlings at both 475 and 540 m were subject to insect attack during their second summer's growth. Insect damage was kept to a minimum by removing all insects each week; however, at both sites, nearby mature trees of *E. delegatensis* provided a source of insects for constant infestation. The main insects involved were leaf-eating Chrysomelidae larvae and sap-sucking *Amorbus* sp. (Hemiptera) adults which destroyed growth apices by feeding on their soft tissues.

DISCUSSION

First Harvest

The results of the first harvest (tables 2, 3, 4A, 5) are difficult to interpret, due in part to the small number (10) of replicates of each soil/elevation combination. In general, dry weight and leaf area production decrease with increase in elevation, with only one notable exception; on the granite soil at 475m, growth was comparable with that at 260m, whereas the growth on the basalt soil was similar to that at 360, 540 and 600m. Probably this superior growth was due to particularly favourable establishment conditions in the granite soil. In terms of major plant nutrients (P and N), the basalt soil is far superior to the granite (table 1); however, structural attributes are also markedly different between soils. Glasshouse trials using a range of tree species, including *E. delegatensis*, have shown that growth is consistently superior on basalt soil, which suggests that soil structure, probably in relationship to establishment, may have been the differentiating factor in the field.

Second Harvest

The results of the second harvest are more clear-cut than for the first, in part due to the increase in sample size to twenty. The significant differences between dry weight on granitic and basaltic soils at 475m have disappeared; however, differences in leaf area are present, due in this case to heavier insect grazing on the granite grown seedlings.

The tendency for dry weight and leaf area production to decrease with increase in elevation is very marked. However, rather than a directly linear relationship, the five elevations can be divided into three groups on the basis of "t" tests between sites. The growth characteristics of seedlings in each group can be summarised as follows :-

Population A

Including all seedlings at 260m

Good dry weight and leaf area production

High net assimilation rate

Population means :

DW : 85.2 ± 13.4 g

LA : 27.08 ± 4.34 sq dm

NAR : 4.16 g sq dm $^{-1}$ week $^{-1}$

Population B

Including all seedlings at 360, 475 and 540m

Medium - poor dry weight and leaf area production

Medium - low net assimilation rate

Population means :

DW : 41.4 ± 2.7 g

LA : 12.27 ± 1.01 sq dm

NAR : 2.03 g sq dm $^{-1}$ week $^{-1}$

Population C

Including all seedlings at 600m

Poor dry weight and leaf area production

Low net assimilation rate

Population means :

DW : 21.6 $\pm$ 2.5 g

LA : 5.95 $\pm$ 0.65 sq dm

NAR : 0.72 g sq dm $^{-1}$ week $^{-1}$

In tables 6 and 7, monthly and annual mean temperatures, and annual rainfall are summarised, for the 74 weeks of the experiment. The mean annual temperatures show a similar type of grouping to that found for seedling growth response, whereas rainfall increases more evenly with increase in elevation. Components of the mean annual temperature most important in reducing plant growth are frequent frosts, and their time of occurrence, and the shortness of the growing season. The growing season is defined as a period of time with mean air temperatures greater than 5.5°C (Baker 1950). If the NAR is to be regarded as the most informative parameter of plant growth measured, the relationship between the populations A: B: C is 6: 3: 1. If the length of the growing season alone is considered for these same elevation populations (based on records kept during the experiment), the corresponding ratios for A: B: C are 4: 3: 2. Clearly, the length of the growing season alone is unsufficient to account for all the variation between populations. In addition the number of frost free months (no temperature below 2.2°C) can be considered for each elevation population. For population A, 5 months are frost free; for population B 2 months, and for population C, no months are frost free. For 11 months of the year population C (600m) was likely to receive a heavy frost (less than 0°C), whereas for population B heavy frosts are likely in 9 months of the year, and for population A for 2 months. At 600m air temperatures below -5°C were likely to be received for two months of the year. During the experiment, individuals at 600m were visibly damaged by frost, once through loss of new spring growth, and twice by the loss of mature leaves in autumn. Both these types of damage severely retard growth.

TABLE 6

Mean monthly temperatures (°C) throughout the experiment (October 1970-May 1972) at each elevation.

	Month												
Elevation	J	F	M	A	M	J	J	A	S	O	N	D	Annual
260	15.5	17.1	14.8	13.9	9.6	7.6	6.5	6.4	6.9	9.9	12.3	14.0	11.2
360	13.9	16.1	14.1	11.5	7.6	6.0	4.9	4.3	5.4	7.6	11.0	13.1	9.6
475	14.3	16.1	13.5	11.3	7.2	6.5	6.3	4.7	5.2	7.9	10.8	12.7	9.7
540	13.9	15.9	13.7	11.4	7.1	6.0	5.1	4.5	5.6	7.7	11.2	13.1	9.6
600	12.5	14.5	12.4	7.9	5.2	3.9	3.1	2.3	4.0	5.2	9.3	12.8	7.7

TABLE 7

Mean annual rainfall (mm) over the period of the experiment (October 1970 - May 1972) at each elevation.

Elevation (m)	Annual Rainfall (mm)
260	1424
360	1470
475	1530
540	1730
600	1860

At all population B sites, some autumn purpling of mature leaves was seen with the first heavy frost. However, these leaves survived, (and, presumably, functioned) well into the following summer. During the last ten months of the experiment, minimum temperatures were recorded at ground level, as well as under screens. The ground minimum at 600m when spring growth was killed, was -10°C, though the screen minimum was only -2°C. Likewise, death of mature leaves in autumn occurred when a ground minimum of -12°C was recorded, with a screen minimum of -4°C. Ground minima as low as this were not recorded elsewhere, though -6°C was common during the winter months at population B sites. Ground minima at 260m even in mid-winter, never fell below -4°C; -1°C was the common winter ground minimum here. The fact that low ground and screen minima are not restricted to the winter season over 600m means that tender spring growth, and mature autumn growth, can both experience low temperatures without the gradual acclimatization of gradually lowering minima, which is the usual situation for populations B and A. Thus it appears that the occurrence of unseasonable frosts over 600m may be sufficient to explain the greater reduction in the growth rate of population C seedlings than might be expected from data on the length of the growing season considered alone.

GENERAL DISCUSSION

The three growth populations of *E. delegatensis* described in this paper can be broadly correlated with the length of the growing season and the degree and duration of frostiness in the Surrey Hills area. Both of these factors are directly influenced by the increasing elevation of the sites under study. The boundary between populations is not clearly defined, due to the limited number of sites used. At least one boundary, between populations B and C, corresponds with a change in physiography from a gently sloping N facing basaltic slope, to an undulating poorly drained basaltic plateau. Along this boundary a change in dominant vegetation type also occurs. On the gentle basaltic slope mixed eucalypt-*Nothofagus cunninghamii* forests are the main plant community, whereas on the plateau top though this community type does occur, pure *Nothofagus* rainforest, or *E. delegatensis* grassy woodlands predominate.

Below 300m, *E. delegatensis* becomes increasingly uncommon, being replaced by *E. obliqua*. Also, *Nothofagus cunninghamii* tends to be restricted to valleys below this elevation. Thus, in a general sense, the boundary between populations A and B marks the transition from wet sclerophyll forests dominated by *E. delegatensis*, to those dominated by *E. obliqua*.

The growth responses observed for seedlings of population B are typical of *E. delegatensis* in areas where it is a successful forest dominant. Over 600m, despite its natural occurrence in mixed forest (eucalypt-*Nothofagus*), wet sclerophyll forest and grassy woodland, evidence is present from poor tree form, poor rates of tree growth (based on stem analyses), infrequency of successful seed set and the poor quality of natural regeneration, to support the hypothesis that *E. delegatensis* in this area is growing near the edge of its natural range. The very poor growth of the experimental seedlings of population C lends further support to this hypothesis.

Although there were no differences in dry weight and leaf area production between soil types at the time of the second harvest, evidence from glasshouse trials suggests that ultimately, growth rates on the granitic soil will fall behind those on basaltic soil. The equal, and occasionally superior, rates of establishment of *E. delegatensis* on granitic soil is an observation of importance in terms of forest management. Much poor tree form and heart rot, which make trees unsuitable for timber production, are probably initiated very early in tree growth, often by heavy insect attack. Vigorous early growth, even on a poor soil type, may counteract the effects of insect damage, so that ultimately good quality timber is produced, although taking longer to reach maturity than on more nutrient-rich soils.

ACKNOWLEDGEMENTS

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TASMANIAN TERTIARY FORAMINIFERA

Part 1. Textulariina, Miliolina, Nodosariacea

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(with four plates)

ABSTRACT

Foraminifera of the Suborders Textulariina and Miliolina and the Superfamily Nodosariacea are recorded from samples of all known Tasmanian marine Oligo-Miocene sections. Thirteen species of agglutinated foraminifera are identified specifically and one category is left in open nomenclature. Thirty species of porcellanous foraminifera (including *Crenulostomina banksi* n. gen., n. sp.) are recorded and there are eight open categories. The Nodosariacea is represented by 63 identified species (including *Lagena tasmaniae* n. sp.) and 10 categories in open nomenclature.

Information on each species includes original citation, synonymy of Australian identifications, remarks where necessary and occurrence and age in Tasmania. All identified forms are figured.

INTRODUCTION AND ACKNOWLEDGEMENTS

The stratigraphy of the Tasmanian Tertiary Marine succession has been reviewed by Quilty (1972). The results noted in that paper are based on foraminiferal studies conducted at the University of Tasmania. Localities, sample numbers etc., mentioned here are detailed further in Quilty (*op. cit.*) and this paper should be read in company with that paper. This paper is the first of a projected series of three papers documenting the Tasmanian Tertiary foraminifera.

Classification adopted in these papers follows closely that proposed by Loeblich and Tappan (1964a) and reviewed by them (1964b) but differs in minor respects which will be indicated where necessary.

Quilty (*op. cit.*) noted that the first record of Tasmanian Tertiary foraminifera was by Goddard and Jensen (1907). In fact Howchin (1893) listed five species from Fossil Bluff and referred to R.M. Johnston's identification of seven genera.

The reference list following the text includes only publications referred to in discussion of species and does not necessarily include those given under synonymy.

The author acknowledges particularly Prof. S.W. Carey and Mr. M.R. Banks, Geology Department, University of Tasmania for their assistance during the earlier phase of this work which was carried out using technical facilities and research funds of the University of Tasmania.

Typing and photographic facilities of West Australian Petroleum Pty. Limited (WAPET) are gratefully acknowledged. Photograph of *Crenulostomina banksi* n. gen., n. sp. and several species of *Lagena* were taken by Mr. W. Copley on WAPET'S JSM

Scanning Electron Microscope. WAPET contributed to the cost of publication of this paper.

ZONATION

When this work was initiated at the University of Tasmania, the only recent advance in zonation of southeastern Australian marine Cainozoic was the formulation of Carter's (1958) Faunal Unit scheme. As this work progressed, the Faunal Unit scheme was formalised into zones by Carter (1964). The study of Tasmanian Tertiary foraminifera was conducted using this zonation.

Since that time, Blow's (1969) comprehensive zonation has appeared and Quilty (1972) attempted to relate Tasmanian faunas to that scheme. A more comprehensive attempt to relate southeastern Australia to international zonation was that by McGowran, Lindsay and Harris (1971). The results given by Quilty (1972) are in agreement with this.

The equivalence used here is as follows:

(a) Carter's *Globoquadrina dehiscens* Zone (Faunal Unit 6) is approximately equivalent to Blow's N4 and N5. Thus Tasmanian material of this age is referred to N4/N5 undifferentiated.

(b) Carter's *Globigerinoides ruber* and *G. transitoria* Zones (Faunal Units 8 and 9 respectively) are approximately equivalent to N8 (taking the base of N9 - the *Orbulina* datum - as the base of Carter's *O. suturalis* Zone - Faunal Unit 10). Exact equivalence has not been established.

(c) Carter's *Globigerinoides trilobus* Zone (Faunal Unit 7) has not yet been recognised in Tasmania.

SYSTEMATIC PALAEONTOLOGY

Introductory Comments

Throughout the systematic section, the "Occurrence" of a species gives -
(a) the locality at which the sample containing the species was collected (detailed in Quilty 1972),
(b) the University of Tasmania, Geology Dept. catalogue number of the sample containing the species, and
(c) a measure of the abundance of the species in the sample.

The measure of the abundance of the species is given by the following symbols -

(v)	the species makes up less than 0.5% of the sample
(r)	" " " " 0.5-2.0% of the sample
(q)	" " " " 2-5% of the sample
(f)	" " " " 5-10% of the sample
(c)	" " " " 10-20% of the sample
(a)	" " " " 20-40% of the sample
(a+)	" " " " 40-80% of the sample
(a++)	" " " " more than 80% of the sample
(p)	the species is present in the sample but the sample is too small for any meaningful estimate of species abundance to be given.

Figured specimens have been selected from samples and catalogued separately.

Suborder TEXTULARIINA
Superfamily LITUOLACEA
Family LITUOLIDAE
Subfamily CYCLAMMININAE
Genus *CYCLAMMINA* Brady, 1879
Cyclammina cf *incisa* (Stache), 1865
(Pl. 1, figs. 1-3)

Haplophragmium incisum Stache, 1865, *"Novara" Expedn, Geol. Theil*, 1, 165, pl. 21, fig. 1.

Cyclammina incisa, Chapman, 1926, *Palaeont. Bull.* Wellington 11, 29, pl. 2, fig. 1.

Cyclammina longicompressa Chapman and Crespin, 1930, *Proc. R. Soc. Vict.*, 43, 97, pl. 5, figs. 3, 4.

Cyclammina incisa Chapman and Crespin, 1932, *Palaeont. Bull.*, Canberra 1, 6, pl. 1, fig. 6.

Cyclammina rotundata Crespin, 1950, *Contr. Cushman Fdn foramin. Res.*, 1, 72, pl. 10, fig. 5.

Cyclammina incisa, Raggatt and Crespin, 1954, *Proc. R. Soc. Vict.*, 67, 119 etc., pl. 7, fig. 3.

Haplophragmoides cf *incisa*, Taylor, 1965, *Proc. R. Soc. Vict.*, 78, 150, fig. 3, nos. 3a, b.

Cyclammina incisa, Hornibrook, 1971, *Palaeont. Bull.* Wellington 43, 34, pl. 6, figs 88-91.

Remarks

The two specimens found here are true *Cyclammina*. They are well preserved, as are all the specimens from the same sample, and there are no adverse diagenetic or weathering affects as listed by Taylor (1965) in his study of Victorian *"Cyclammina"* faunas. Preservation is such that good sections can be cut and these show the primary structure of the wall, not the product of some later alteration. The specimens found are rather large (1-1.5 mm) completely involute, with 10-11 chambers in the final whorl and are slightly asymmetrical with a smooth surface. The slight asymmetry is present in both specimens and may well be a primary feature, not a preservation phenomenon, as suggested by Taylor. It is interesting to note that this true *Cyclammina* is here found in very shallow water sediments.

Crespin's (1950) figure of *Cyclammina rotundata* has more than eight chambers in the final whorl (more likely 11-12) and thus does not agree with Taylor's diagnosis of that species in which he suggests that six to eight chambers are present in the final whorl. However Chapman and Crespin's (1930) type description of C *rotundata* mentions eight chambers (or sutures) in the final whorl. Thus Crespin's (1950) specimen, referred to C. *rotundata*, is more likely to be C. cf *incisa*.

Occurrence - Fossil Bluff - 84010a (v).

Age - Early Miocene, N 4/5.

Maximum diameter of figured specimens

(a) Complete specimen 1.2 mm
(b) wall section 0.92 mm

Repository - (a) U.T.G.D. 84138
(b) U.T.G.D. 84484

Subfamily COSCINOPHRAGMINAE

Genus *BDELLOIDINA* Carter, 1877

Bdelloidina aggregata Carter, 1877

(Pl. 1, fig. 4)

Bdelloidina aggregata Carter, 1877, *Ann. Mag. nat. Hist.*, ser. 4, 19, 201, 208, pl. 13, figs. 1-8.

Bdelloidina aggregata, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.* 9, 319, pl. 36, figs. 4-6.

Bdelloidina aggregata, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, p. 6.

Bdelloidina aggregata, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924) pt. 2, 135.

Bdelloidina aggregata, Todd and Low, 1960, *Prof. Pap. U.S. Geol. Surv.*, 260-X, 827, pl. 263, fig. 8.

Remarks

The specimens found here are more similar to Carter's type figure and Todd and Low's figured specimen than to Brady's figured specimen. It is probably the same species as that recorded by Howchin.

Occurrence - Mussel Roe Bay - 84483 (v).

Age - Late Oligocene - Early Miocene, N3-5.

Maximum diameter of figured specimen 3.8 mm.

Repository - U.T.G.D. 84472.

Family TEXTULARIIDAE

Subfamily TEXTULARIINAE

Genus *TEXTULARIA* Defrance, 1824

Textularia fistulosa Brady, 1884

(Pl. 1, figs. 5, 6)

Textularia sagittula Defrance var. *fistulosa* Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9. 362, pl. 42, figs. 19-22.

Textularia sagittula var. *fistulosa*, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 7.

Spiroplecta sagittula, Defr. var. *fistulosa* Chapman, 1907, *Jl Linn. Soc.*, 30, 27, pl. 3, fig. 60

Textularia fistulosa, Crespin, 1943, *Palaeont. Bull.*, Canberra 4, 83.

Remarks

Heron-Allen and Earland (1924, p. 136) also make reference to this form in discussing the presence of *T. sagittula* in their "Filter Quarry" material. In the

numerous specimens recovered, no actual fistulose growths were seen, but their positions are marked by an open pore on the ends of many chambers.

Occurrence - Mussel Roe Bay 84483 (f), 84481 (v).

Age - Late Oligocene - Early Miocene, N3-5.

Figured specimen from 84483.

Maximum diameter of figured specimen 0.72 mm.

Repository - U.T.G.D. 84474.

Textularia gramen d'Orbigny, 1846

(Pl. 1, fig. 7)

Textularia gramen d'Orbigny, 1846, *Foraminiferes fossiles du Bassin Tertiare de Vienne (Autriche)*, Gide and Co.: Paris, 248, pl. 15, figs. 4-6.

Textularia gramen, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 137.

For more complete synonymy, see Ellis and Messina (1940 *et seq.*).

Remarks

This name is used for a species which occurs sporadically throughout all sections examined in Tasmania. It seems to be the same species as that referred to by Heron-Allen and Earland (1924, *op. cit.*). It does not correspond well with any other described Australasian species and seems to fit within the compass of this species.

Occurrence - (a) Mussel Roe Bay - 84481 (q), 84482 (f),
(b) Fossil Bluff section - 84010a (r), 84010b (v), 84025a (v), 84024 (v),
(c) King Island - 84083 (v),
(d) Mt Cameron West - 84118 (r), 84120 (v),
(e) Marrawah - 84092 (v), 84108 (q), 84109 (q), 84110 (c), 84111 (r), 84113 (q), 84114 (f), 84115 (r), 84104 (q), 84105 (f), 84106 (c), 84107 (q).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 0.72 mm.

Repository - U.T.G.D. 84139.

Textularia cf *hayi* Karrer, 1864

(Pl. 1, figs. 8, 9)

Textularia hayi Karrer, 1864, *"Novara" Expedn, Geol. Theil*, 1,78, pl. 16, fig. 7.

?Textularia rugosa, Chapman, 1907, *Jl Linn. Soc.*, 30, 27, pl. 3, fig. 57.

Textularia marsdeni Finlay, 1939, *Trans. R. Soc. N.Z.*, 69, (1), 90, pl. 14. fig. 67.

Textularia marsdeni, Finlay and Marwick, 1940, *Trans. R. Soc. N.Z.*, 70, (1), 118.

Textularia marsdeni, Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 16, pl. 1, fig. 7.

Textularia hayi, Hornibrook, 1971, *Palaeont. Bull.*, Wellington, 43, 15, pl. 1. figs. 1-7.

Remarks

The specimens recovered here are very similar to the older half of Finlay's (1939) type figure, and also very similar to Chapman's (1907) figure of *T. rugosa* and Hornibrook's (1961) figure of *T. marsdeni*. It seems highly probable that all occurrences belong to the one species.

Occurrence - (a) Cape Grim - 84008 (r), 84007 (r), 84006 (r), 84005 (v), 84001 (v),
(b) Mt Cameron West - 84117 (r).

Age - Early Miocene, N4/5.

Figured specimen from 84008

Maximum diameter of figured specimen 0.75 mm.

Repository - U.T.G.D. 84140.

Textularia praelonga Reuss, 1845

(Pl. 1, fig. 10)

Textularia praelonga Reuss, 1845, *Die Versteinerungen der bohmischen Kreide-formation*, E. Schweizerbart: Stuttgart, Abth. 1, 39, pl. 12, figs. 14 a, b.

Textularia praelonga, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 137.

For a more complete synonymy, see Ellis and Messina (1940 *et seq.*).

Remarks

Two specimens have been referred to this species.

Occurrence - Fossil Bluff - 84024 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.70 mm.

Repository - U.T.G.D. 84141.

Textularia spp

Remarks

The few specimens recorded under this heading cannot be placed in the species otherwise listed here, usually because of poor or incomplete preservation.

Occurrence - (a) Mussel Roe Bay - 84483 (v), 84481 (r),
(b) King Island - 84476 (r),

(c) Preservation Island - 84479 (v),

(d) Brittons Swamp - 84480 (r).

Late Oligocene - Early Miocene.

Genus *SEMIVULVULINA* Finlay, 1939

Semivulvulina capitata (Stache), 1865

(Pl. 1, Fig. 11)

Textilaria capitata Stache, 1865, *"Novara" Expedn Geol. Theil*, 1 (2), 272, pl. 24, fig. 19

Vulvulina (Semivulvulina) capitata, Finlay, 1939, *Trans. R. Soc. N.Z.*, 68, 505.

Vulvulina (Semivulvulina) capitata, Loeblich and Tappan, 1964, *Treat. Invert. Palaeont.*, C2 (1), C 254, fig. 165, 10-12.

Vulvulina (Semivulvulina) capitata, Hornibrook, 1971, *Palaeont Bull.*, Wellington, 43, 31, pl. 5, fig. 76

Remarks

There is no doubt that this is the species figured by Loeblich and Tappan (1964a) as *S. capitata* (Stache). Stache's (1865) original figures look a little different and this may be one of the other species of *Semivulvulina*.

Occurrence - Marrawah area - 84104 (r). 84105 (r).

Age - Early Miocene, N8.

Figured specimen from 84104.

Maximum diameter of figured specimen 0.57 mm.

Repository - U.T.G.D. 84142.

Subfamily PSEUDOBOLIVININAE

Genus *SIPHOTEXTULARIA* Finlay, 1939

Siphotextularia aff. *bolivina* Hornibrook, 1961

(Pl. 1, fig. 12)

Siphotextularia bolivina Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 22, pl. 2, figs. 18, 23.

Remarks

Only 4 specimens of this species were recovered. The apertural characters, wall characters etc., correspond almost exactly with those listed by Hornibrook (1961) for *S. bolivina*. The only difference between these specimens and the New Zealand species is one of length/width ratio. The New Zealand species is relatively longer. The Tasmanian specimens are very similar to the older half of Hornibrook's holotype. The Tasmanian and New Zealand species are clearly very closely related and may be the same thing.

Occurrence - (a) Mussel Roe Bay - 84483 (v),
(b) Fossil Bluff - 84010b (v), 84011 (v),

Age - Late Oligocene - Early Miocene, N3-5.

Figured specimen from Mussel Roe Bay.

Maximum diameter of figured specimen 0.40 mm.

Repository - U.T.G.D. 84143.

Family TROCHAMMINIDAE

Subfamily TROCHAMMININAE

Genus *AMMOSPHAEROIDINA* Cushman, 1910

Ammosphaeroidina sphaeroidiniformis (Brady), 1884

(Pl. 1, fig. 13)

Haplophragmium sphaeroidiniformis Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 313.

Haplophragmium sphaeroidiniformis, Howchin, 1889, *Trans. R. Soc. S. Aust.*, 12, 6.

Haplophragmium sphaeroidiniforme, Chapman, 1907, *Jl Linn. Soc.*, 30, 24, pl. 3, figs. 50-51.

Ammosphaeroidina sphaeroidiniformis, Cushman, 1910, *Bull, U.S. natn. Mus.*, 71 (1), 24.

Ammosphaeroidina sphaeroidiniformis, Loeblich and Tappan, 1964, *Treat. Invert. Paleont.* C2 (1), C 259, fig. 174, 1.

Ammosphaeroidina sphaeroidiniformis, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 65.

Remarks

The details of this species are by no means clear as it has an indistinct aperture and very coarsely arenaceous rough surface. It is identified mainly by its similarity to the figures in Chapman (1907) (*op. cit.*)

Occurrence - (a) Mussel Roe Bay - 84481 (v),
(b) Marrawah district - 84113 (v), 84101 (r).

Age - Early Miocene, N4/5,8.

Figured specimen from 84113.

Maximum diameter of figured specimen 0.52 mm.

Repository - U.T.G.D. 84144.

Family ATAXOPHRAGMIIDAE

Subfamily VERNEULININAE

Genus *GAUDRYINA* d'Orbigny, 1839

Gaudryina convexa (Karrer), 1865

(Pl. 1, figs. 14, 15)

Textilaria convexa Karrer, 1865, *"Novara" Expedn Geol. Theil*, 1, 78, pl. 16, figs. 8 a-c.

(non Gaudryina convexa Karrer: Cushman, 1911, *Bull. U.S. natn. Mus.*, 71 (2), 66, fig. 105)

Gaudryina crespinae, Cushman, 1936, *Spec. Publns Cushman Lab.*, 6, 14, pl. 2, figs. 15 a, b.

Gaudryina convexa, Burdett *et al.*, 1963, *N. Zealand Jl Sci.*, 6 4, 513-530.

Gaudryina convexa, Hornibrook, 1971, *Palaeont. Bull*, Wellington, 43, 16, pl. 1, figs. 8-15.

Remarks

Burdett *et al. (op. cit.)* gave an idea of the problems associated with systematics and synonymy of this species. I have followed them here in their broad concept of *G. convexa*, although Reed (1965) did not. The synonymy presented here is very incomplete, as is also that in Burdett *et al.*. Only those references which seem to have any relevance at all are listed. The general range of specimens is probably closest to *G. crespinae* which may possibly be considered as a subspecies. It is common in the Tasmanian material.

More than one type of specimen is present. In 84093 (Redpa), the specimens have very clear, depressed sutures and slightly concave sides. In all other samples, they have much less distinct sutures and flat (generally) or even convex (occasionally) sides. A specimen of each type is figured.

Occurrence - (a) Mussel Roe Bay - 84483 (f), 84481 (f), 84482 (f),
(b) King Island - 84084 (v), 84085 (r), 84082 (r), 84083 (c), 84086 (q), 84475 (q), 84476 (f), 84477 (q),
(c) Daisy Creek - 84478 (r),
(d) Cape Grim - 84008 (v), 84006 (v),
(e) Mt Cameron West - 84118 (r), 84120 (r), 84117 (q),
(f) Granville Harbour - 54144 (r),
(g) Preservation Island - 84479 (v),
(h) Redpa - 84097 (v), 84093 (r), 84095 (r), 84096 (v),
(i) Marrawah district - 84092 (r), 84109 (r), 84110 (r), 84111 (r), 84113 (q), 84104 (q), 84101 (q), 84105 (r), 84106 (r), 84107 (q).

Age - Late Oligocene - Early Miocene, N3-8.

Figured specimen from (a) Redpa (84093) and (b) Marrawah (84104).

Maximum diameter of figured specimens (a) 0.87 mm.
(b) 0.60 mm.

Repository - (a) U.T.G.D. 84145,
(b) U.T.G.D. 84146.

Genus *TRITAXIA* Reuss, 1860

Tritaxia victoriensis (Cushman), 1936

(Pl. 1, figs. 16, 17)

Clavulina angularis, Chapman, 1907, *Jl Linn. Soc.*, 30, 29, pl. 4, figs. 68-73.
(The upper of the two specimens labelled 69, should be 70.)

Clavulinoides szaboi (Hantken) var. *victoriensis* Cushman, 1936, *Spec. Publs Cushman Lab.*, 6, 22, pl. 3, figs. 19, 22.

Clavulinoides victoriensis, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, pl. 4, fig. 4.

Clavulinoides victoriensis, Reed, 1965, *Bull. Am. Paleont.*, 49, (220), 73, pl. 11, figs. 2, 9.

Remarks

Several well preserved specimens were recovered from Mussel Roe Bay, Mt Cameron West and Marrawah.

Cushman (1948) considered that two genera - *Tritaxia* and *Clavulinoides* - could be distinguished. Glaessner (1945) and Pokorny (1958) also followed this usage, but Loeblich and Tappan (1964a) place the two genera in synonymy. The differences between them as earlier envisaged do seem to be rather minor and they are here considered as being congeneric.

Occurrence - (a) Mussel Roe Bay - 84483 (v),
(b) Fossil Bluff - 84010b (v),
(c) Mt Cameron West - 84121 (v), 84120 (q), 84117 (r),
(d) Marrawah - 84109 (r).

Age - Late Oligocene - Early Miocene, N3-5, N8.

Figured specimen from Mt Cameron West (84120).

Maximum diameter of figured specimen 1.35 mm.

Repository - U.T.G.D. 84147.

Subfamily GLOBOTEXTULARIINAE

Genus *DOROTHIA* Plummer, 1931

Dorothia parri Cushman, 1936

(Pl. 1, figs. 18, 19)

Dorothia parri Cushman, 1936, *Spec. Publns Cushman Lab.*, 6, 29, 30, pl. 4, figs. 19a, b.

Dorothia parri, Crespin, 1954, *Rep. Bur. Miner. Resour. Geol. Geophys. Aust.*, 11, 3-5.

Dorothia parri, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 49, 56, 63, etc.

Gaudryina (Gaudryina) heywoodensis Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 71, pl. 11, figs. 1, 13.

Remarks

Bowen's (1965) suggestion that *Dorothia* and *Gaudryina* are congeneric, is probably untenable. The main difference (a clear one) seems to be that *Dorothia* begins with a trochoid coil (whether 3, 4, 5 ... chambers means little) which is followed by an appreciable number of pairs of chambers arranged biserially, whereas *Gaudryina* has an early portion consisting of several triserial whorls (more than one) followed by a later portion consisting of a few or several, regular or irregular, pairs of chambers arranged biserially. Most species are clearly one genus or the other but in some cases differentiation is difficult and the generic name not very dependable. On the belief that *Dorothia* and *Gaudryina* are distinct, Reed's (1965) name *Gaudryina (Gaudryina) heywoodensis* lapses. It is very widespread species in Tasmanian Tertiary sediments.

Occurrence - (a) Mussel Roe Bay - 84483 (q), 84481 (r), 84482 (q),
(b) Fossil Bluff - 84010a (v), 84011 (v), 84012 (r), 84024 (v),
(c) King Island - 84477 (r),
(d) Cape Grim - 84006 (v),
(e) Mt Cameron West- 84120 (r), 84117 (r),
(f) Marrawah district - 84092 (v), 84109 (q), 84110 (q), 84113 (r), 84114 (v), 84104 (v), 84101 (r), 84105 (r), 84106 (f), 84107 (v).

Age - Late Oligocene - Early Miocene, N3-8.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 1.25 mm.

Repository - U.T.G.D. 84148.

Subfamily VALVULININAE

Genus *PSEUDOCLAVULINA* Cushman, 1936

Pseudoclavulina cf *anglica* Cushman, 1936

(Pl. 1, figs. 20, 21)

Pseudoclavulina anglica Cushman, 1936, *Spec. Publns Cushman Lab.*, 6, 18, pl. 3, fig. 5.

Pseudoclavulina anglica, Hornibrook, 1958, *N.Z. Jl Geol. Geophys.*, 1, (4), 654, figs. 1,2.

?Pseudoclavulina rudis, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 72, pl. 11, figs 3, 6, 12, 14.

Remarks

A few poorly preserved specimens have been found, of a species very much like that figured in both Cushman (1936, *op. cit.*) and Hornibrook (1958, *op. cit.*). On the single specimen with a well preserved aperture the aperture is terminal, roughly rounded, but without a distinct valvuline tooth. On the other hand it has a rounded uniserial portion and an indistinct early triserial portion. Thus it is distinct from both *Tritaxia* and *Clavulina*. Cushman's genus *Pseudoclavulina* is used herein for this species although Loeblich and Tappan (1964a, p. C279) regard this genus as synonymous with *Clavulina*.

Occurrence - Fossil Bluff - 84010b (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 1.67 mm.

Repository - U.T.G.D. 84485.

Suborder MILIOLINA

Superfamily MILIOLACEA

Family FISCHERINIDAE

Genus *CYCLOGYRA* Wood, 1842

Cyclogyra involvens (Reuss), 1850

(Pl. 1, fig. 22)

Operculina involvens Reuss, 1850, *Denkschr. Akad. Wiss.*, Wien, 1, 370, pl. 46, fig. 20.

Cornuspira involvens, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 200, pl. 11, figs. 1-3.

Cornuspira involvens, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 350.

Cornuspira involvens, Chapman, 1907, *Jl Linn. Soc.*, 30, 22, 23, pl. 2, fig. 46.

Cornuspira involvens, Reed, 1965, *Bull. Am. Paleont.*, 49, (220), 66.

Remarks

Following Loeblich and Tappan (1964a, p. C438) the genus *Cornuspira* Schultze is regarded as synonymous with *Cyclogyra* Wood, hence *Cornuspira involvens* (Reuss) becomes *Cyclogyra involvens* (Reuss). The species is well preserved in the Fossil Bluff section.

Occurrence - Fossil Bluff - 84010a (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.65 mm.

Repository - U.T.G.D. 84149.

Family NUBECULARIIDAE

Subfamily SPIROLOCULININAE

Genus *SPIROLOCULINA* d'Orbigny, 1826

Spiroloculina angulata Cushman, 1917

(Pl. 1, fig. 23)

Spiroloculina grata, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 155, pl. 10, figs. 16, 17, 22, 23.

Spiroloculina grata var. *angulata* Cushman, 1917, *Bull. U.S. natn. Mus.*, 71, 36, pl. 7, fig. 5.

Spiroloculina angulata Cushman and Todd, 1944, *Spec. Publns Cushman Lab.*, 11, 50.

Remarks
This species is generally well preserved, especially at Fossil Bluff (84010a) where the specimens are often coloured black along the longitudinal striae and chamber junctions (see pl. 1, fig. 23). Whether this colouration is due to original colouring or to secondary development of framboidal pyrite is hard to decide.

Occurrence - (a) Fossil Bluff - 84010a (v),
(b) Cape Grim - 84008 (q), 84007 (r), 84002 (r), 84001 (r).

Age - Early Miocene, N4/5.

Figured specimen from 84010a.

Maximum diameter of figured specimen 1.45 mm.

Repository - U.T.G.D. 84150.

Spiroloculina rotunda d'Orbigny, 1826

(Pl. 1, fig. 24)

Frumentaria sigma Soldani, 1795, *Testaceographiae ac* ..... Tomi Primi pars tertia, Rossi: Siena, 229, pl. 154, figs. hh, ii.

Spiroloculina rotunda d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 299.

Spiroloculina rotunda, Parker, Jones and Brady, 1871, *Ann. Mag. nat. Hist.*, ser. 4, 8, pl. 8, fig. 25.

Remarks
This species does not seem to have been recorded from Australia before. It is probably a varient of *S. depressa* d'Orbigny, or *S. canaliculata* d'Orbigny, both of which it resembles.

Occurrence - Fossil Bluff - 84011 (r).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.81 mm.

Repository - U.T.G.D. 84151.

Spiroloculina cf *sublimbata* Parr, 1950

(Pl. 1, fig. 25)

Spiroloculina limbata Parr, 1950, *Rep. B.A.N.Z. Antarct. Res. Expedn*, 1929-1931 ser. B, 5 (6), 291, pl. 6, figs. 14a-c.

Remarks
This species is tentatively identified as *S. sublimbata* as only one complete specimen was found. From the side view it is very similar to *S. canaliculata* but differs

from it in having a third central keel in the outer part of each chamber. *S. sublimbata* seems to be the only species in which this feature is clearly shown.

Occurrence - Cape Grim - 84002 (v), 84001 (v).

Age - Early Miocene, N4/5.

Figured specimen from 84002.

Maximum diameter of figured specimen 0.52 mm.

Repository - U.T.G.D. 84153.

Spiroloculina tenuiseptata Brady, 1884

(Pl. 1, fig. 26)

Spiroloculina tenuiseptata Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 153, pl. 10, figs. 5, 6.

?Spiroloculina canaliculata, Carter, 1958, *Bull. geol. Surv. Vict.*, 55, 30, pl. 2, figs. 1, 2.

Spiroloculina tenuiseptata, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 74.

Remarks

This species is distinct from *S. depressa* d'Orbigny in having an elliptical aperture without tooth, rather than having a round to square aperture with tooth, and from *S. canaliculata* d'Orbigny in having depressed sutures and chambers with convex sides.

The few specimens recovered are seldom well preserved, but the figured specimen is quite well preserved and is notable in that the last two chambers are arenaceous.

The specimen figured by Carter (1958, *op. cit.*) shows depressed sutures and convex sides to the chambers, and appears more likely to be *S. tenuiseptata* than *S. canaliculata*. On the other hand, Chapman's (1907, pl. 1, figs. 20, 21) illustrations are very convincing as figures of *S. canaliculata*.

Occurrence - Fossil Bluff - 84011 (r), 84013 (r), 84015 (r).

Age - Early Miocene, N4/5.

Figured specimen from 84015.

Maximum diameter of figured specimen 0.80 mm.

Repository - U.T.G.D. 84152.

Spiroloculina acutimago Brady, 1884

(Pl. 1, fig. 27)

Spiroloculina acutimago Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 154, pl. 10 fig. 14.

Spiroloculina acutimago, Chapman, 1907, *Jl. Linn. Soc.*, 30, 16, pl. 1, fig. 19.

Spiroloculina tenuirostra, Heron Allen and Earland, 1924, *Jl Linn. Soc.*, 35, 604.

Spiroloculina sp. abnorm., Barker, 1960, *Spec. Publns Soc. econ. Paleont. Miner.*, Tulsa, 9, pl. 10, fig. 14.

Remarks

Specimens almost identical with Brady's (1884, pl. 10, fig. 14) figure are present in two samples from Fossil Bluff. It seems probable that they are not abnormal specimens, as suggested by Barker (1960), but constitute a species in their own right.

Occurrence - Fossil Bluff - 84011 (v), 84012 (r).

Age - Early Miocene, N4/5.

Figured specimen from 84012.

Maximum diameter of figured specimen 0.48 mm.

Repository - U.T.G.D. 84154.

Spiroloculina spp

Remarks

This category is used to include all those specimens not identifiable below generic level but which are obviously *Spiroloculina*. They are recorded mainly in an effort to help calculate fairly accurate ratios of miliolids to other species for ecological interpretations. A similar category is used for unidentifiable *Quinqueloculina*, *Triloculina*, miliolids etc.

Occurrence - (a) Mussel Roe Bay - 84483 (v),
(b) Fossil Bluff - 84013 (r), 84015 (q), 84016 (r).

Age - Late Oligocene - Early Miocene.

Family MILIOLIDAE

Subfamily QUINQUELOCULININAE

Genus *CRENULOSTOMINA* Quilty, n. gen.

Genoholotype: *Crenulostomina banksi* n. sp.

Generic Diagnosis

Test free, quinqueloculine in chamber arrangement; wall imperforate, microgranular calcite with porcellanous appearance. Wall without outer agglutinated layer. Aperture terminal, circular, with (in the type species) a weakly developed tooth in the proximal part. Margin of aperture deeply crenulate.

Remarks

This genus is dintinct from *Dentostomina* Carman in having no agglutinated outer layer to the wall. It is distinct from *Quinqueloculina* in having a deeply crenulate margin to the aperture. In dealing with the new species, three alternatives presented themselves.

(a) Emend *Dentostomina* to include non-agglutinated species,
(b) Emend *Quinqueloculina* to include apertures with crenulate margins,
(c) Erect a new genus.

The latter choice was taken, in preference to the first, as *Dentostomina* and *Crenulostomina* are probably different lineages from a quinqueloculine stock, the stock of *Crenulostomina* being akin to *Q. singletoni* Crespin. Emendation of *Quinqueloculina* does not seem advisable. It is a large genus badly in need of effective subdivision. Adding the character of crenulate aperture only increases the need for subdivision. This step would also render *Dentostomina* synonymous with *Quinqueloculina*.

Derivation of name - *crenula* - little notch (L); *stoma* - mouth (L from Gr.).

Crenulostomina banksi Quilty, n. sp.

(Pl. 1, figs. 28-33)

Diagnosis

Test quinqueloculine in chamber arrangement, very elongate with length/width ratio of a little over three. Chambers approximately semicircular in section, each end extending over the ends of the previously formed test. Chambers with five to seven longitudinal costae, in earlier chambers, reducing to one to four in the last two or three chambers.

Description

Test free elongate, with length of 0.7-2.0 mm and width (maximum diameter perpendicular to length) of 0.24-0.52 mm, giving a length/width ratio of 3.0-3.6. Chamber arrangement quinqueloculine, three chambers visible from one side (the middle two visible for about three-quarters and three-fifths of test length respectively).

Growth axis remains fixed throughout ontogeny and chambers are added parallel to it. Chambers elongate, only about one-tenth as wide as long; semicircular in section; patterned with longitudinal costae which in later chambers may be as few as one to four, often with more at each end than in the middle, some costae dying out before reaching the middle of the chamber. Earlier chambers with five to seven costae. Chamber surface between costae commonly with very fine pits which are often coarser in the vicinity of the sutures which are very clear. Growth sometimes a little irregular. Aperture terminal, large, circular with crenulated margin and weak tooth in the proximal part.

Remarks

Of seven specimens recovered, three are from sample 84012 and are quite iron stained and unclear. The other four are from 84010a and are very well preserved and all have been included in the type collection. As only these few are available, none has been sectioned.

Occurrence - Fossil Bluff - 84010a (r), 84012 (r).

Age - Early Miocene, N4/5.

Holotype and three paratypes from 84010a.

Maximum diameter of (a) holotype 1.80 mm,
(b) figured paratype 1.92 mm.

Repository - (a) U.T.G.D. 84156,
(b) U.T.G.D. 84157,
(c) Other paratypes 84155, 84158.

Genus *PYRGO* Defrance, 1824

Pyrgo elongata (d'Orbigny), 1826

(Pl. 2, figs. 34, 35)

Biloculina elongata d'Orbigny, *Annls Sci. nat.* ser., 1, 7, 298.

Biloculina elongata, Parker, Jones and Brady, 1871, *Ann. Mag. nat. Hist.*, ser. 4, 8, pl. 8, fig. 6.

?Biloculina elongata, Chapman, 1907, *Jl Linn. Soc.*, 30, 15, pl. 1, fig. 14.

Remarks
A few very poorly preserved specimens are tentatively referred to this species. Overall test length and apertural characters are compatible with the identification. Another possible identification is *P. myrrhyna* (Schwager).

Occurrence - (a) Cape Grim - 84008 (v), 84002 (v),
(b) Marrawah district - 84114 (v).

Age - Early Miocene, N4-8.

Figured specimen from Cape Grim (84008).

Maximum diameter of figured specimen 0.45 mm.

Repository - U.T.G.D. 84170.

Pyrgo inornata (d'Orbigny), 1846

(Pl. 2, fig. 36)

Biloculina inornata d'Orbigny, 1846, *Foraminiferes fossiles du Bassin Tertiaire de Vienne (Autriche)*, Gide and Co.: Paris, 266, pl. 16, figs. 7-9.

Pyrgo inornata, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 74.

Remarks
A few poorly preserved specimens were recovered. None is preserved well enough to allow study of apertural details.

Occurrence - (a) Brittons Swamp - 84480 (v),
(b) Marrawah district - 84113 (r), 84114 (r).

Age - Early Miocene, N8.

Figured specimen from the Marrawah district (84113).

Maximum diameter of figured specimen 0.36 mm.

Repository - U.T.G.D. 84171.

Pyrgo sarsi (Schlumberger), 1891
(Pl. 2, fig. 37)

Biloculina sarsi Schlumberger, 1891, *Mem. Soc. Zool. Fr.*, 4, 553, figs. 55-59, text figs. 10-12.

Biloculina sarsi, Chapman, 1907, *Jl Linn. Soc.*, 30, 14, pl. 1, figs. 1, 2.

Biloculina bradii, Chapman, 1907, *op. cit.*, 13, pl. 1, figs. 7, 8.

Biloculina laevis, Chapman, 1907, *op. cit.*, 14, pl. 1. figs. 15.

Biloculina depressa, Chapman, 1907, *op. cit.*, 14, pl. 1, fig. 16.

Biloculina sarsi, Heron-Allen and Earland, 1924, *Jl, R. microsc. Soc.*, (1924), pt. 2, 131.

Pyrgo sarsi, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 50.

Pyrgo sarsi, Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 61, pl. 1, figs. 10, 11.

Pyrgo sarsi, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), p. 66.

Occurrence - (a) Fossil Bluff - 84010a (v),
(b) Cape Grim - 84008 (v),
(c) Marrawah district - 84113 (v), 84104 (v), 84101 (r).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84010a)

Maximum diameter of figured specimen 0.95 mm.

Repository - U.T.G.D. 84172.

Pyrgo vespertilio (Schlumberger), 1891
(Pl. 2, fig. 38)

Biloculina ringens, Brady, 1884, *"Challenger" Espedn, Scient. Results, Zool.*, 9, 142, pl. 11, fig. 8.

Biloculina vespertilio Schlumberger, 1891, *Mem. Soc. zool. Fr.*, 4, 561, pl. 10, figs. 74-76.

Biloculina ringens, Chapman, 1907, *Jl Linn. Soc.*, 30, 13, pl. 1, figs. 9, 10.

Pyrgo vespertilio, Thalmann, 1932, *Eclog. geol. Helv.*, 25, 295.

Pyrgo vespertilio, Crespin, 1943, *Palaeont. Bull.*, Canberra 4, 81.

Occurrence - (a) Fossil Bluff - 84010a (v), 84010b (v),
(b) Brittons Swamp - 84480 (v).

Age - *Early Miocene, N4-8.*

Figured specimen from 84010b.

Maximum diameter of figured specimen 0.50 mm.

Repository - U.T.G.D. 84173.

Pyrgo sp.

Remarks
Poorly preserved unidentifiable specimens were recovered from each of the samples 84554 (r), 84110 (v), 84111 (v), 84101 (v).

Age - Early Miocene, N8.

Genus *QUINQUELOCULINA* d'Orbigny, 1826

Quinqueloculina angularis d'Orbigny, 1826
(Pl. 2, figs. 39, 40)

Quinqueloculina angularis d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 302, no. 3.

Quinqueloculina angularis, Fornasini, 1905, *Memorie R. Accad. Sci. Ist. Bologna.*, ser. 6, 2, 66, pl. 3, fig. 12.

Occurrence - (a) Fossil Bluff - 84011 (r), 84006 (v), 84001 (r).

Age - Early Miocene, N4/5.

Figured specimen from 84008.

Maximum diameter of figured specimen 0.60 mm.

Repository - U.T.G.D. 84159.

Quinqueloculina angulostriata Cushman and Valentine, 1930
(Pl. 2, figs. 41, 42)

Quinqueloculina angulo-striata Cushman and Valentine, 1930, *Contr. Dep. Geol. Stanford Univ.*, 1 (1), 12, pl. 2, figs. 5 a-c.

Remarks
In three samples, specimens were recovered which are difficult to name accurately, even though well preserved. They seem to be halfway between *Q. striata* d'Orbigny and *Q. angulostriata*. While being finely striate, they do have angular ridges on the test, but not so strongly developed as in typical *Q. angulostriata*.

Occurrence - (a) Fossil Bluff - 84010b (r), 84012 (v),
(b) Cape Grim - 84008 (v).

Age - Early Miocene, N4/5/

Figured specimen from Fossil Bluff (84010b).

Maximum diameter of figured specimen 0.60 mm.

Repository - U.T.G.D. 84160.

Quinqueloculina aspera d'Orbigny, 1826

(Pl. 2, figs. 43, 44)

Frumentaria semiluna Soldani, 1795, *Testaceographiae ac* ..... Tomi Primi pars tertia, Rossi: Siena, 228, pl. 152, fig. B.

Quinqueloculina aspera d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 301.

Quinqueloculina aspera, Parker, Jones and Brady, 1871, *Ann. Mag. nat. Hist.*, ser. 4, 8, pl. 8, fig. 11.

Remarks

Three well preserved specimens were recovered from Fossil Bluff (84011) in which the species is very rare.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 1.48 mm.

Repository - U.T.G.D. 84161.

Quinqueloculina bradyana Cushman, 1917

(Pl. 2, figs. 45, 46)

Miliolina undosa Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 176, pl. 6, figs. 6-8.

Quinqueloculina bradyana Cushman, 1917, *Bull. U.S. natn. Mus.*, 71, 52, pl. 18, fig. 2.

Remarks

From Brady's figures of the species it seems probable that this species is simply an irregular varient of *Q. cuvieriana*. In this study, the species is recorded from one sample only. In this sample (84008, Cape Grim), it does not show the elongate aperture and tooth (Brady, 1884, pl. 6, fig. 6) but has an aperture more like that illustrated by Brady (*op. cit.* fig. 8).

Occurrence - Cape Grim - 84008 (r).

Age - Early Miocene, N4/5.

Maximum diameter of figured speciman 0.59 mm.

Repository - U.T.G.D. 84162.

Quinqueloculina cuvieriana d'Orbigny, 1839

(Pl. 2, figs. 47, 48)

Quinqueloculina cuvieriana d'Orbigny, *in* de la Sagra, 1839, *Histoire physique, politique et naturelle de L'ile de Cuba*, A. Bertrand: Paris, 8, 190, pl. 11, figs. 19-21.

Quinqueloculina lamarckiana d'Orbigny, (*op. cit.*), 8, 189, pl. 11, figs. 14, 15.

Miliolina cuvieriana, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 162, pl. 5, figs. 7, 12.

Miliolina cuvieriana, Chapman, 1907, *Jl. Linn. Soc.*, 30, 19, pl. 2, fig. 33.

Quinqueloculina lamarckiana, Cushman, 1922, *Publns Carnegie Instn.*, 311, 64.

Quinqueloculina cuvieriana, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 65.

Remarks

Barker (1960, p. 10) suggested that *Q. lamarckiana* d'Orbigny has page priority over *Q. cuvieriana.* According to Article 24(a) of the I.C.Z.N. the "relative priority is determined by the action of the first reviser". Brady placed *Q. lamarckiana* in the synonymy of *Q. cuvieriana,* cited both names and chose one name *(Q. cuvieriana)* as the name of the taxon. Under these conditions Brady must surely satisfy the requirements of "first reviser" as set out in I.C.Z.N. Art. 24(a) (i). Thus Cushman (1922) is not the first reviser, and his action in giving priority to *Q. lamarckiana* is invalid.

Barker (1960) placed two forms in this species. One is a short species (Pl. 5, fig. 12) and the other (Pl. 5, fig. 7) is a longer one. Barker's usage is employed here. However, no intermediates seem to exist and it may be that the two are distinct species as envisaged by Brady (1884) when he placed the former type in *Miliolina cuvieriana* and the latter in *M. venusta.*

Occurrence - (a) Fossil Bluff - 84010a (q), 84010b (v), 84011 (f), 84012 (r), 84013 (q), 84016 (r), 84025a (q),
(b) Cape Grim - 84008 (v), 84007 (q), 84006 (r), 84001 (q),
(c) Marrawah district - 84111 (v).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 0.30 mm.

Repository - U.T.G.D. 84163.

Quinqueloculina granulosa Natland, 1938

(Pl. 2, figs. 49, 50)

Quinqueloculina granulosa Natland, 1938, *Bull. Scripps Instn Oceanogr. Tech. Ser.*, 4 (5), 141, pl. 4, fig. 1.

Remarks

This species is very common in the Tasmanian Tertiary. It agrees very well with Natland's (1938) description, varying from 0.35 to 0.60 mm in length and 0.20 to 0.35 mm in width. It also has a smooth surface, apparently very rare in arenaceous miliolids. Within the samples, a large variation is found in the amount by which early chambers jut out between the last two chambers. This is due to a variation in the extent to which each chamber covers the preformed test. A glance at a few isolated specimens easily gives the erroneous impression that one is dealing with a new species. Body form varies from typical *Q. granulosa* to forms very similar to *Siphonaperta macbeathi* Vella or *Q. mauricensis* Howe var. *lisbonensis* Cushman and Todd. However the smooth surface seems to be almost a unique feature.

The size, smooth surface and arenaceous test of this species are reminiscent of *Sigmoilopsis chapmani* (Cushman) (Reed 1965). However it is a true *Quinqueloculina.* It is possible that the *Q. granulosa* and *S. chapmani* have sometimes been confused.

Occurrence - (a) Fossil Bluff - 84010b (r), 84011 (q), 84012 (v), 84013 (r), 84025a (r),
(b) Cape Grim - 84008 (v), 84001 (v),
(c) Marrawah district - 84113 (v), 84106 (r).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84010b).

Maximum diameter of figured specimen 0.57 mm.

Repository - U.T.G.D. 84164.

Quinqueloculina laevigata d'Orbigny, 1839
(Pl. 2, fig. 51)

Quinqueloculina laevigata d'Orbigny (*in* Barker-Webb and Berthelot, 1839), *Histoire Naturelle des Iles Canaries*, Bethany: Paris, 2 (2), 143, pl. 3, figs. 31-33.

Occurrence - Cape Grim - 84002 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.60 mm.

Repository - U.T.G.D. 84165.

Quinqueloculina seminulum (Linne), 1758
(Pl. 2, figs. 52,53)

Serpula seminulum Linne, 1758, *Systema Naturae* (10th ed.) 1, 786.

Miliolina seminulum, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.* 9, 157, pl. 5, figs. 6a-c.

Miliolina seminulum, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 2.

Miliolina seminulum, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 350.

Miliolina seminulum, Chapman, 1907, *Jl Linn. Soc.*, 30, 19, pl. 2, fig. 34.

Quinqueloculina seminulum, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.

Quinqueloculina seminulum, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 50.

Remarks

Q. seminulum here includes such forms as *Q. schreiberiana* d'Orbigny, but excludes *Q. vulgaris* d'Orbigny, which is distinguished here in having a more carinate margin to the chambers and in having a very clearly visible fourth chamber on one side of the test, whereas *Q. seminulum* is less carinate and has the fourth chamber either not visible or only faintly visible.

The species is probably the most abundant miliolid in the Tasmanian Tertiary.

Occurrence - (a) Fossil Bluff - 84010a (f), 84010b (c), 84011 (v), 84102 (f), 84013 (v), 84015 (r), 84016 (r).

(b) Cape Grim - 84008 (q), 84002 (r), 84001 (q),
(c) Brittons Swamp - 84480 (r).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 1.30 mm.

Repository - U.T.G.D. 84166.

Quinqueloculina simplex Terquem, 1882
(Pl. 2, figs. 54, 55)

Quinqueloculina simplex Terquem, 1882, *Mem. Soc. geol. France*, ser. 3, 2 (3), 172, pl. 18, figs. 5-13.

Occurrence - (a) Fossil Bluff - 84010a (q), 84010b (r), 84013 (v),
(b) Cape Grim - 84008 (r), 84002 (r), 84001 (r).

Age - Early Miocene, N4/5.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 0.85 mm.

Repository - U.T.G.D. 84167.

Quinqueloculina vulgaris d'Orbigny, 1826
(Pl. 2, figs. 56, 57)

Quinqueloculina vulgaris d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 302, no. 33.

Miliolina vulgaris, Chapman, 1907, *Jl Linn. Soc.*, 30, 18, pl. 2, fig. 32.

Quinqueloculina vulgaris, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.

Quinqueloculina vulgaris, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 51.

Quinqueloculina vulgaris, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 66.

Remarks
See *Q. seminulum*.

Occurrence - (a) Fossil Bluff - 84010a (r), 84010b (v),
(b) Cape Grim - 84002 (r).

Age - Early Miocene, N4/5.

Figured specimen from Fossil Bluff (84010b).

Maximum diameter of figured specimen 1.05 mm.

Repository - U.T.G.D. 84168.

Quinqueloculina sp. 1

(Pl. 2, fig. 58)

? Miliolina ferussacii, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 175, pl. 113, fig. 17a, b.

? Quinqueloculina sp. nov ? Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 234, pl. 113, fig. 17a, b.

Remarks

A very elongate species similar in overall test characters is found in two samples (84008 (v) and 84006 (v)) from Cape Grim. However, instead of one, two or three strong longitudinal ridges in each of the last chambers, it has very many fine striae and may thus represent a different undescribed species.

Age - Early Miocene, N4/5.

Figured specimen from 84008.

Maximum diameter of figured specimen 1.30 mm.

Repository - U.T.G.D. 84169.

Quinqueloculina spp.

Miliolid and planktonic species are more susceptible to breakage than other types and although not identifiable at generic or specific level in several cases, their abundances are recorded to help calculate relative abundances at the family or superfamily level for each sample.

Occurrence - (a) Mussel Roe Bay - 84483 (q), 84482 (v),
(b) Fossil Bluff - 84010a (q), 84011 (v), 84012 (r), 84013 (q), 84019 (q), 84023 (c), 84025a (r), 84025b (r),
(c) Daisy Creek - 84478 (q),
(d) Cape Grim - 84007 (r), 84006 (r), 84005 (r),
(e) Marrawah district - 84111 (r), 84113 (r), 84114 (r).

Age - Late Oligocene - Early Miocene.

Genus *SIGMOILINA* Schlumberger, 1887

Sigmoilina obesa Heron-Allen and Earland, 1932

(Pl. 2, figs. 59-64)

Sigmoilina obesa Heron-Allen and Earland, 1932, *"Discovery" Reps*, 4, 320, pl. 7 figs. 1-4.

Sigmoilina obesa, Earland, 1933, *"Discovery" Reps*, 7, 49.

Sigmoilina obesa, Earland, 1934, *ibid.*, 10, 50.

Sigmoilina obesa, Earland, 1936, *ibid.*, 13, 22, pl. 1, figs. 2-4.

Sigmoilina obesa, Cushman, 1946, *Contr. Cushman Lab. foramin. Res.*, 22 (2), 43, pl. 6 figs. 29-31.

Remarks

From the exterior, small specimens of this species are indistinguishable generically from *Pyrgo*. Two small specimens were sectioned. One (megalospheric) consisted of a large, spherical proloculus 0.15 mm in diameter followed by only one pair of chambers, so no sigmoidal arrangement was seen. The other specimen is microspheric with a pyrite filled proloculus 0.05 mm in diameter. This shows a sigmoidal arrangement. Thus the species belongs to *Sigmoilina*. Larger specimens are clearly distinct from *Pyrgo* as one side of the test shows three chambers and has very shallow, almost flush sutures, while the other side shows two chambers with a broadly, deeply depressed suture between.

That this species should occur here at all seems a little anomalous. Dorman (1966) listed temperatures, based on O^{16}/O^{18} ratios for Victorian specimens, in this part of the geological column of 15-20°C. This species is now a predominantly Antarctic one, living in much colder waters.

Occurrence - (a) Fossil Bluff - 94010b (r), 84011 (v), 84012 (r), 84013 (v), 84014 (r), 84016 (r), 84025b (v),
(b) Cape Grim - 84001 (v).

Age - Early Miocene, N4/5.

Figured specimens from (a) 84010b
(b) 84010b
(c) 84011
(d) 84010b

Maximum diameter of figured specimens
(a) complete microspheric specimen 0.58 mm,
(b) complete megalospheric specimen 0.35 mm,
(c) megalospheric section 0.36 mm,
(d) microspheric section 0.24 mm.

Repository - (a) U.T.G.D. 84176,
(b) U.T.G.D. 84177,
(c) U.T.G.D. 84175,
(d) U.T.G.D. 84174.

Sigmoilina victoriensis Cushman, 1946
(Pl. 2, figs. 65, 66)

Planispira sigmoidea, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 5.

Sigmoilina sigmoidea, Chapman, 1907, *Jl Linn. Soc.*, 30, 20, 21, pl. 2, fig. 40.

Sigmoilina sigmoidea, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924) pt. 2, 133.

Sigmoilina sigmoidea, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.

Sigmoilina sigmoidea (H.B. Brady) var. *compressa*, Cushman, 1946, *Contr. Cushman Lab. foramin. Res.*, 22 (2), 32, pl. 5, figs. 10-12.

Sigmoilina victoriensis Cushman, 1946, *ibid.*, 22 (3), 103.

Sigmoilina victoriensis Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 66.

Remarks

From an examination of the seven specimens recovered, it seems almost as if Cushman's splitting of this species from *S. sigmoidea s.s.* is unwarranted. Within the specimens there is a range from specimens identical with the type specimens of *S. victoriensis* to those which are identical with Brady's (1884) or Cushman's (1946) figures of *Sigmoilina sigmoidea s.s.* However, the typological species can be recognised, and all variants of it are placed in this species. Thus *Sigmoilina sigmoidea s.s.* probably also occurs here. The Marrawah specimen is an internal mould and the identification is tentative only.

Occurrence - (a) Fossil Bluff - 84010b (v), 84011 (v),
(b) Cape Grim - 84002 (v),
(c) Marrawah district - 84111 (v).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84010b).

Maximum diameter of figured specimen 0.38 mm.

Repository - U.T.G.D. 84178.

Genus *SIPHONAPERTA* Vella, 1957

Siphonaperta ammophila (Parr), 1932
(Pl. 2, figs. 67, 68)

Quinqueloculina ammophila Parr, 1932, *Proc. R. Soc. Vict.* n.s., 44, 8, pl. 1, fig. 10.

Quinqueloculina ammophila, Howchin and Parr, 1938, *Trans. R. Soc. S. Aust.*, 62 (2), 291, 292, pl. 15, figs. 3, 4.

Quinqueloculina ammophila, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 82.

Siphonaperta ammophila, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.* 36, 71, pl. 6, fig. 2.

Remarks

Loeblich and Tappan (1964a, pl C466) record this genus as a Pleistocene to Recent one. As long ago as 1943, Crespin *(op. cit.)* had recorded this species in Batesfordian rocks and this record (also one from Ludbrook, pers. comm.) shows it to be in Early Miocene, Longfordian rocks.

This species stands out among arenaceous forms, as one which apparently at will selects and incorporates in its test a high proportion of dark particles. Among dark minerals it seems quite partial to biotite flakes.

Occurrence - (a) Fossil Bluff - 84010a (r), 84013 (q), 84025b (v),
(b) Cape Grim - 84001 (v).

Age - Early Miocene, N4/5.

Figured specimen from Fossil Bluff (84010a)

Maximum diameter of figured specimen 0.70 mm.

Repository - U.T.G.D. 84179.

Genus *SPIROSIGMOILINA* Parr, 1942

Spirosigmoilina tateana (Howchin), 1889

(Pl. 2, figs. 69-71)

Spiroloculina tateana Howchin, 1889, *Trans. Roy. Soc. S. Aust.*, 12, 3, pl. 1, figs. 4, 5.

Sigmoilina tateana, Howchin , 1929, *The geology of South Australia*, The author: Adelaide, Fig. 108, figs. 4, 5.

Spirosigmoilina tateana, Parr, 1942, *Min. geol. Jl*, 2 (6), 361.

Spriosigmoilina tateana, Loeblich and Tappan, 1964, *Treat. Invert. Paleont.*, C2 (1), C466, fig. 353, 5.

Remarks

About 100 specimens are referred to this species, all from the lower part of the Fossil Bluff section. Specimens are of two types, here taken as being microspheric and megalospheric. The microspheric form is represented by a single specimen which is figured. It is the typical form of the species and has all the characters of the genus, i.e. a sigmoiline initial part and later spiroloculine part. However the dominant form of the species does not have a sigmoiline initial part but consists of an enrolled tube. This type is consistently smaller than the microspheric type. The megalospheric form begins with a proloculus followed by an enrolled planispiral tube which grows by discontinuous growth. At every 120° to 180°, the growth has halted and the wall is strongly thickened. Thus the individual growth units (chambers) are 120 - 180° long, usually nearer to 180° but earlier ones often nearer to 120°. These chambers are in turn subdivided into chamberlets by transverse septa, there being about four to five chamberlets in each adult chamber. I have not determined whether or not these are true septa or simply thickenings of the chamber wall. There is no external expression of these septa.

The more abundant form of the species does not fit the generic diagnosis at all. The form is consistent with a position in the Fischerininae (*sensu* Loeblich and Tappan) or in the genus *Heterillina*, or even in *Cornuloculina*. The aperture does not show the hauerine trematophore. The megalospheric specimens are almost identical externally with *Hauerina fragilissima* (Brady).

Thus it is possible that *Spirosigmoilina* is biologically invalid, being only the microspheric form of some other genus. It it is valid, it must be emended to include the megalospheric form thus rendering the "typical" form atypical.

Occurrence - Fossil Bluff - 84010b (r), 84011 (c), 84012 (v), 84013 (q), 84014 (v), 84015 (r).

Age - Early Miocene, N4/5.

Figured specimens from (a) 84010b (microspheric),
(b) 84011 (megalospheric).

Maximum diameter of figured specimens (a) 0.95 mm,
(b) 0.30 mm.

Repository - (a) U.T.G.D. 84188.
(b) U.T.G.D. 84187.

Genus *TRILOCULINA* d'Orbigny, 1826

Triloculina affinis d'Orbigny, 1850

(Pl. 2, figs. 72, 73)

Triloculina affinis d'Orbigny, 1850, *Prodome de paleontologie stratigraphique universelle des animaux mollusques et rayonnes*, V. Masson: Paris, 3, 161.

Triloculina affinis, Fornasini, 1905, *Memorie R. Accad. Sci. Ist. Bologna*, ser. 6, 2, pl. 1, fig. 1.

Occurrence - Cape Grim - 84008 (r), 84006 (v), 84001 (v).

Age - Early Miocene, N4/5.

Figured specimen from 84006.

Maximum diameter of figured specimen 0.45 mm.

Repository - U.T.G.D. 84181.

Triloculina brochita Carter, 1964

(Pl. 2, figs. 74, 75)

Triloculina brochita Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 59, pl. 1, figs. 3, 4.

Triloculina brochita, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 73.

Remarks

Only in the large adult form (such as the figured specimen) does the species become identical with the holotype figured by Carter *(op. cit.)*. In small specimens, the chambers are not quite so inflated and their margins are a little less rounded as a result of it.

Occurrence - (a) Fossil Bluff - 84010a (r), 84011 (r), 84013 (q), 84014 (q) 84025a (v), 84024 (v), 84017 (r)

(b) Cape Grim - 84008 (v), 84006 (v), 84002 (v), 84001 (r),

(c) Marrawah district - 84101 (v).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84011).

Maximum diameter of figured specimen 0.92 mm.

Repository - U.T.G.D. 84142.

Triloculina laevigata d'Orbigny, 1878

(Pl. 2, figs. 76, 77)

Triloculina laevigata d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 134.

Triloculina laevigata, Terquem, 1878, *Mem. Soc. geol. Fr.*, ser. 3, 1 (3), 57, pl. 5, figs. 20, 21.

Remarks
In a few samples from Fossil Bluff and Cape Grim, are found specimens of an elongate *Triloculina* very much like *T. consobrina* d'Orbigny or *T. elongata* d'Orbigny. However, it differs from these species in possessing a clearly bifid tooth, not the simple tooth of the latter species, and is therefore placed in *T. laevigata*.

Occurrence - (a) Fossil Bluff - 84010b (r),
(b) Cape Grim - 84008 (r), 84006 (v).

Age - Early Miocene, N4/5.

Figured specimen from 84008.

Maximum diameter of figured specimen 0.62 mm.

Repository - U.T.G.D. 84185.

Triloculina rotunda d'Orbigny, 1893
(Pl. 2, figs. 78, 79)

Triloculina rotunda d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 299, No. 4.

Triloculina rotunda Schlumberger, 1893, *Mem. Soc. zool. Fr.*, 6, 64, pl. 1, figs. 48-50.

Occurrence - Cape Grim - 84008 (q), 84006 (r), 84002 (q), 84001 (r),

Age - Early Miocene, N/45.

Figured specimen from 84008.

Maximum diameter of figured specimen 0.72 mm.

Repository - U.T.G.D. 84183

Triloculina trigonula (Lamarck), 1804
(Pl. 2, figs. 80, 81)

Miliolites trigonula Lamarck, 1804, *Ann. Mus. natn. Hist. nat.*, Paris 5, 351, (figs. Vol. 9, pl. 17, figs. 4a-c, 1807).

Triloculina trigonula, d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 299, pl. 16, figs. 5-9.

Miliolina trigonula, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 2.

Miliolina trigonula, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 350.

Miliolina trigonula, Chapman, 1907, *Jl Linn. Soc.*, 30, 18, pl. 2, fig. 30.

Miliolina trigonula, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 131.

Triloculina trigonula, Howchin and Parr, 1938, *Trans. R. Soc. S. Aust.*, 62 (2), 305.

Triloculina trigonula, Crespin, 1943, *Palaeont. Bull.*, 4, 84.

Triloculina trogonula, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 50, 79.

Triloculina trigonula, Reed, 1961, *Bull. Am. Paleont.*, 49 (220), 73.

Occurrence - (a) Fossil Bluff - 84010a (r), 84010b (f), 84011 (r), 84012 (v), 84013 (r), 84016 (r),
(b) Cape Grim - 84008 (v), 84002 (r),
(c) Marrawah district - 84113 (r), 84114 (v), 84101 (r).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 0.66 mm.

Repository - U.T.G.D. 84184.

Triloculina sp 1

(Pl. 3, figs. 82, 83)

Remarks

From Cape Grim (84001 (v)) a few specimens of a very inflated species were recovered. They look very much like *T. brochita* Carter but have an obvious, bifid tooth. Occasionally the wall of the chambers is 'crinkled' giving an irregular pattern to the otherwise smooth surface of the test. It may be a variety of *T. rotunda*.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.53 mm.

Repository - U.T.G.D. 84186.

Triloculina spp

Remarks

What has been said for *Quinqueloculina* spp and *Spiroloculina* spp also holds for unidentified specimens of *Triloculina*.

Occurrence - Fossil Bluff - 84010a (r), 84013 (v), 84019 (r), 84023 (q).

Age - Early Miocene.

Subfamily *MILIOLINELLINAE*

Genus *MILIOLINELLA* Wiesner, 1931

Miliolinella subrotunda (Montagu), 1803

(Pl. 3, figs. 84, 85)

Vermiculum subrotundum Montagu, 1803, *Testacea Brittanica* ....., J.S. Hollis: Romsey, England, 521.

Miliolinella subrotunda Wiesner, 1931, *Deutsche Sudpolar Expedn, Zool.*, 12, 63, 65, 107.

Remarks

This appears to be the only Australian record of this species. Chapman (1907) and Reed (1965) record *M. oblonga* (Montagu).

Occurrence - Cape Grim - 84008 (r), 84002 (r), 84001 (r).

Age - Early Miocene, N4/5.

Figured specimen from 84008.

Maximum diameter of figured specimen 0.52 mm.

Repository - U.T.G.D. 84180.

Subfamily TUBINELLINAE

Genus *ARTICULINA* d'Orbigny, 1826

Articulina carinata Wiesner, 1923

(Pl. 3, fig. 86)

Articulina sagra d'Orbigny var. *carinata* Wiesner, 1923, *Die Milioliden der oestlichen Adria*, H. Wiesner: Prague, 74, pl. 19, fig. 188.

Remarks

Two specimens of this species were recovered from Fossil Bluff (84010b). Of the described Australian species, it is closest to *A. parri* Cushman but lacks such features as spiral costae, which although not expressly mentioned by Cushman (1944) as a specific character, are clear in his figures of the species.

Wiesner's variety is herein raised to specific rank, as there seems to be more difference between it and *A. sagra s.s.* than, for example between *A. sagra* and *A. parri* or between *A. sagra* and *A. victoriana* Cushman.

In the specimens recovered, the aperture and its lip are missing.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.78 mm.

Repository - U.T.G.D. 84189.

Articulina sp.

(Pl. 3, fig. 87)

Remarks

A single unidentifiable specimen was recovered from Fossil Bluff (84013). It consists of a single cylindrical chamber 0.52 x 0.15 mm with a strongly everted lip to its aperture. It is the final chamber of a specimen and is 'ornamented' with several longitudinal striae which are all continuous throughout the length of the specimen. The closest species appears to be *A. canui* Cushman.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.52 mm.

Repository - U.T.G.D. 84190.

Unidentified miliolids

Remarks

These are noted in an effort to reconstruct the ratios of families etc. to each other, so that a reconstruction of palaeoecology can be attempted, taking into account all the characters available of foraminiferal distributions. See also *Quinqueloculina*, *Triloculina* and *Spiroloculina*.

Occurrence - (a) Fossil Bluff - 84010a (q), 84014 (q), 84015 (q), 84016 (f), 84017 (q), 84022 (r), 84023 (c), 84025a (r),
(b) Cape Grim - 84008 (r), 84006 (r), 84003 (q), 84002 (f), 84001 (v),
(c) Granville Harbour - 54144 (f),
(d) Brittons Swamp - 84480 (f),
(e) Marrawah district - 84108 (a+), 84109 (r), 84111 (r), 84114 (r), 84115 (r), 84104 (r), 84105 (r), 84106 (r).

Age - Early Miocene.

Suborder ROTALIINA

Superfamily NODOSARIACEA

Family NODOSARIIDAE

Subfamily NODOSARIINAE

Genus *DENTALINA* Risso, 1826

Dentalina advena (Cushman), 1923
(Pl. 3, fig. 89)

Nodosaria (Dentalina) roemeri, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 505, pl. 63, fig. 1.

Nodosaria advena Cushman, 1923, *Bull. U.S. natn. Mus.*, 104 (4), 79, pl. 14, fig. 12.

Dentalina advena, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 132, pl. 63, fig. 1.

Occurrence - (a) Mussel Roe Bay - 84483 (v),
(b) Cape Grim - 84008 (v), 84007 (r), 84006 (v),
(c) Marrawah district - 84092 (v).

Age - Late Oligocene - Early Miocene, N3-5.

Figured specimen from Cape Grim (84007).

Maximum diameter of figured specimen 0.70 mm.

Repository - U.T.G.D. 84195.

Dentalina cf *divergens* Reuss, 1865

(Pl. 3, fig. 88)

Dentalina divergens Reuss, 1965, *Sber, Akad. Wiss.*, Wien, 50 (1), 456, pl. 4, fig. 10.

Remarks

Dentalina divergens is the most similar described species to that found here. The present species is much more arcuate than *D. divergens* in the one complete specimen recorded. It also has a much smaller portion, only the first one or two chambers,

patterned with spiral grooves. It is probably a new species but, as only two specimens are known, it is given this tentative identification.

Occurrence - Cape Grim - 84008 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 1.95 mm.

Repository - U.T.G.D. 94098.

Dentalina filiformis (d'Orbigny), 1826

(Pl. 3, fig. 90)

Nodosaria filiformis d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 253.

Nodosaria filiformis, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 500, pl. 63, figs. 3-5.

Dentalina filiformis, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9,

Remarks

The name is used here for the same species that Brady illustrated and listed. The chambers seem to be much more elongate than in the species figured by Parker, Jones and Brady (1871) as *Dentalina filiformis*, and it may well be that later workers have used the name for a different species than d'Orbigny intended.

Occurrence - (a) Fossil Bluff - 84011 (v), 84013 (v),
(b) Cape Grim - 84008 (v).

Age - Early Miocene, N4/5.

Figured specimen from Fossil Bluff (84011).

Maximum diameter of figured specimen 1.15 mm.

Repository - U.T.G.D. 84196.

Dentalina godjeni Quilty, 1969

(Pl. 3, fig. 91)

Nodosaria roemeri Neugeboren var. *semicostata* Goddard and Jensen, 1907, *Proc. Linn. Soc. N.S.W.*, 32, (2), 313, pl. 6, fig. 14.

Dentalina godjeni Quilty, 1969, *Pap. Proc. Roy. Soc. Tasm.*, 103, 97, fig. 2.

Occurrence - (a) Mussel Roe Bay - 84483 (r),
(b) Fossil Bluff - 84010a (v), 84010b (v).

Age - Late Oligocene - Early Miocene, N3-5.

Figured topotype from Fossil Bluff (84010a).

Maximum diameter of figured specimen 4.4 mm.

Repository - U.T.G.D. 84293.

Dentalina obliqua (Linné), 1758
(Pl. 3, fig. 92)

Nautilus obliquus Linné, 1758, *Systema Naturae* ....., 10th edn, G. Engelman: Lipsiae, 1, 701.

Nodosaria (Dentalina) obliqua, Chapman and Parr, 1926, *Jl. Linn. Soc.*, 36, 384, pl. 19, fig. 46.

Dentalina obliqua, Howchin and Parr, 1938, *Trans. R. Soc. S. Aust.*, 62 (2), 298, pl. 16, fig. 5.

Dentalina obliqua, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 78.

Remarks
A single large incomplete specimen about 5.8 mm long was recovered from Mussel Roe Bay (84483 (v)).

Age - Late Oligocene, N3.

Repository - U.T.G.D. 84294.

Dentalina semirugosa (d'Orbigny), 1846
(Pl. 3, fig. 93)

Nodosaria semirugosa d'Orbigny, 1846, *Foraminiferes fossiles du Bassin Tertiaire de Vienne (Autriche)*, Gide and Co: Paris, 34, pl. 1, figs. 20-23.

Nodosaria costulata, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 515, pl. 63, figs. 23-27.

Dentalina guttifera (d'Orbigny) var. *semirugosa*, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 134, pl. 63, figs. 23-27.

Remarks
There seems to be no good reason why the specific name of this species should not be the one d'Orbigny intended for it. Admittedly, calling it a variety of *D. guttifera* probably does express a relationship, but no adequate reason for reducing its rank from species to variety seems to have been put forward. Thus after a circuitous trip through the taxonomic hierarchy, this species is approximately back to where it started.

The bend in the axis of the species is so slight that even the generic change from *Nodosaria* to *Dentalina* is mainly a pedantic one.

Occurrence - Fossil Bluff - 84012 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.62 mm.

Repository - U.T.G.D. 84197.

Dentalina subcostata Chapman, 1926

(Pl. 3, fig. 94)

Nodosaria (Dentaline) obliqua Linne var. *subcostata* Chapman, 1926, *Palaeont. Bull.*, Wellington, 11, 51, pl. 11, fig. 3.

Dentalina subcostata, Finlay, 1946, *Trans. R. Soc. N.Z.* 76 (2), 243.

Dentalina subcostata, Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 45, pl. 6, fig. 88.

Occurrence - Fossil Bluff - 84010a (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 2.90 mm.

Repository - U.T.G.D. 84537.

Dentalina subsoluta (Cushman), 1923

(Pl. 3, fig. 95)

Nodosaria subsoluta Cushman, 1923, *Bull. U.S. natn. Mus.*, 104 (4), 74, pl. 13, fig. 1.

Nodosaria soluta, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 155.

Nodosaria (Dentalina) soluta, Chapman and Parr, 1926, *Jl Linn. Soc.*, 36, 383, pl. 19, fig. 40.

Dentalina soluta, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 78.

Occurrence - Mussel Roe Bay, 84483 (v).

Age - Late Oligocene, N3.

Maximum diameter of figured specimen 2.1 mm.

Repository - U.T.G.D. 84295.

Genus *DIMORPHINA* d'Orbigny, 1826

Dimorphina sp.

(Pl. 3, fig. 96)

Remarks

A single poorly preserved specimen is referred to this genus. It does not appear

to belong to any previously defined genus. It may be a *Marginulina* as the detail of the early chambers is not clear.

Occurrence - Marrawah district - 84110 (v).

Age - Early Miocene, N8.

Maximum diameter of figured specimen 0.55 mm.

Repository - U.T.G.D. 84199.

Genus *LAGENA* Walker and Jacob, 1798

Lagena aspera Reuss, 1862

(Pl. 3, fig. 97)

Lagena aspera Reuss, 1862, *Sber. Akad. Wiss.*, Wien, 44 (1), 305, pl. 1, fig. 5.

Lagena aspera, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Remarks

The species recorded here seems to be identical with one figured by Brady (1884, pl. 57, fig. 11) and Barker (1960) as *L. aspera*. It seems close to *L. aspera* var. *spinifera* Chapman, in that it has a spherical test with short neck. However, no spines are evident.

Occurrence - Mussel Roe Bay - 84483 (v).

Age - Late Oligocene, N3.

Maximum diameter of figured specimen 0.29 mm.

Repository - U.T.G.D. 84371.

Lagena hexagona (Williamson), 1848

(Pl. 3, fig. 98)

Entosolenia squamosa (Montagu) var. *hexagona* Williamson, 1848, *Ann. Mag. nat. Hist.*, ser. 2, 1, 20, pl. 2, fig. 23.

Lagena hexagona, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 8.

Lagena hexagona, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 351.

Lagena hexagona, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Lagena hexagona, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 19.

Remarks

The practice of taxonomists in listing this species has been to give Williamson the credit for placing the species in *Lagena* by not putting his name in parentheses after the specific name. Williamson placed the species in *Entosolenia*. The position is similar to a case in which var. *hexagona* Williamson is first given full specific rank within the genus *Entosolenia* and becomes *Entosolenia hexagona* Williamson. A later revisor would then change the generic assignation from *Entosolenia* to *Lagena*. Williamson's name then should be placed in parentheses.

Occurrence - (a) Mussel Roe Bay - 84483 (v),
(b) Fossil Bluff - 84011 (v), 84012 (r), 84022 (v), 84024 (v),
(c) Mt. Cameron West - 84118 (r),
(d) Granville Harbour - 54144 (q),
(e) Redpa - 84096 (v),
(f) Marrawah district - 84105 (v).

Age - Late Oligocene - Early Miocene, N3-8.

Figured specimen from Fossil Bluff (84011).

Maximum diameter of figured specimen 0.30 mm.

Repository - U.T.G.D. 84486.

Lagena hispida Reuss, 1863
(Pl. 3, fig. 99)

Lagena hispida Reuss, 1863, *Sber. Akad. Wiss.*, Wien., 46 (1), 335, pl. 6, figs. 77-79.

Lagena hispida, Chapman and Parr, 1926, *Jl Linn. Soc.*, 36, 375, pl. 17, fig. 9.

Lagena hispida, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Occurrence - (a) Fossil Bluff - 84015 (q), 84019 (v), 84024 (v), 84025b (v),
(b) Redpa - 84095 (v).

Age - Early Miocene, N4/5, N8.

Figured specimen from Fossil Bluff (84019).

Maximum diameter of figured specimen 0.32 mm.

Repository - U.T.G.D. 84200.

Lagena hispidula Cushman, 1913
(Pl. 3, fig. 100)

Lagena laevis, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 455, pl. 56, figs. 10, 11.

Lagena hispidula Cushman, 1913, *Bull. U.S. natn. Mus.*, 71 (3), 14, pl. 5, figs. 2, 3.

Remarks
One well preserved, finely hirsute specimen from Fossil Bluff (84013) is referred to this species.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.27 mm.

Repository - U.T.G.D. 84203.

Lagena laevis (Montagu), 1803

(Pl. 3, figs. 101, 102)

Serpula (Lagena) laevis ovalis Walker and Boys, 1784, *Testacea minuta .....*, J. March: London, 3, pl. 1, fig. 9.

Vermiculum laeve, Montagu, 1803, *Testacea Brittanica .....*, J.S. Hollis: Romsey, England, 524.

Lagena laevis, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 351.

Lagena laevis, Chapman and Parr, 1926, *Jl Linn. Soc.*, 36, 373, pl. 17, fig. 1.

Lagena laevis, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Lagena laevis, Crespin, 1954, *Rep. Bur. Miner. Resour. Geol. Geophys. Aust.*, 11, 4.

Lagena laevis, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 118, pl. 57, figs. 14, 16-18, 23, 25-27.

Remarks

In this work, this species has been interpreted rather widely following Barker *(op. cit.)*. Two specimens are figured. The Marrawah record is doubtful as the two specimens are very poorly preserved.

Occurrence - (a) Fossil Bluff - 84010 (v), 84011 (v), 84015 (r), 84019 (v), 84025b (v),
(b) Mt Cameron West - 84120 (v),
(c) Marrawah district - 84109 (r), 84114 (v).

Age - Early Miocene, N4-8.

Figured specimens from Fossil Bluff (a) 84010a,
(b) 84011.

Maximum diameter of figured specimens (a) 0.32 mm,
(b) 0.35 mm.

Repository - (a) U.T.G.D. 84202,
(b) U.T.G.D. 84201.

Lagena mariae Karrer, 1877

(Pl. 3, fig. 103)

Lagena mariae Karrer, 1877, *Abh. geol. Bundesanst.*, Wien, 9, 378, pl. 166, fig. 16.

Remarks

Only one poorly preserved specimen was recovered from King Island (84081) and is very tentatively referred to this species.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.48 mm.

Repository - U.T.G.D. 84204.

Lagena montagui Silvestri, 1902

(Pl. 3, fig. 104)

Lagena montagui Silvestri, 1902, *Memorie Accad. pont. Nuovi Lincei*, 19, 153, figs. 40-43.

Remarks
A single well preserved specimen with a strongly raised irregular network of ridges on its surface, is referred to this species. It is in part reminiscent of a coarse *L. hexagona* but the pits between ridges are irregular polygons not regular hexagons.

Occurrence - Fossil Bluff - 84013 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.35 mm.

Repository - U.T.G.D. 84205.

Lagena striata (d'Orbigny), 1839

(Pl. 3, fig. 105)

Oolina striata d'Orbigny, 1839, *Voyage dans l'Amerique Meriodionale-Foraminiferes*, Pitois Levrault and Co: Paris.

Lagena striata, Chapman and Parr, 1926, *Jl. Linn. Soc.*, 36, 374, pl. 17, fig. 5.

Lagena striata, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Lagena striata, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 118, pl. 57, figs. 19, 22, 24, 28.

Lagena striata, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 19.

Lagena striata, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 67.

Remarks
This species, as with *L. laevis*, is interpreted in the broad sense, as is done by Barker (1960).

Occurrence - Fossil Bluff - 84010b (v), 84013 (v), 84014 (r), 84024 (v).

Age - Early Miocene, N4/5.

Figured specimen from 84013.

Maximum diameter of figured specimen 0.40 mm.

Repository - U.T.G.D. 84206.

Lagena sulcata (Walker and Jacob), 1798

(Pl. 3, fig. 106)

Serpula (Lagena) striata, sulcata, rotunda Walker and Boys, 1784, *Testacea minuta* ....,

J. March: London, 2, pl. 1, fig. 6.

Serpula (Lagena) sulcata Walker and Jacob, 1798, *Adams' essays on the microscope*, Dillon and Keating: London, 2nd edn., 634, pl. 14, fig. 5.

Vermiculum striatum Montagu, 1803, *Testacea Brittanica .....*, J.S. Hollis: Romsey, England, 523.

Lagena sulcata, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 8.

Lagena sulcata, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 351.

Lagena sulcata, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 149, pl. 9, fig. 35.

Lagena sulcata, Chapman and Parr, 1926, *Jl. Linn. Soc.*, 36, 375, pl. 17, fig. 6.

Lagena sulcata, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Lagena sulcata, Crespin, 1954, *Rep. Bur. Miner. Resour. Geol. Geophys. Aust.*, 11, 4.

Lagena sulcata, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 19.

Lagena sulcata, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 67.

Remarks

The name *Vermiculum striatum* Montagu, 1803 is apparently a senior homonym of *L. sulcata* (d'Orbigny), 1839. However usage would probably be a sufficient criterion for validity.

Occurrence - (a) Fossil Bluff - 84011 (v), 84024 (v), 84025b (v),
(b) Mt Cameron West - 84117 (r),
(c) Redpa - 84096 (v).

Age - Early Miocene, N4-8.

Figured specimen from Fossil Bluff (84011).

Maximum diameter of figured specimen 0.25 mm.

Repository - U.T.G.D. 84207.

Lagena tasmaniae Quilty n. sp.

(Pl. 3, fig. 107)

Diagnosis

Lagena characterised by having about 15 spiral ridges, twisting through 90° from neck to basal pole, these ridges being perforated by numerous, radial pores, the test surface between the ridges being smooth.

Description

Test free, small, unilocular, composed of very nearly spherical chamber 0.19 mm in diameter, with a neck 0.05 mm long and 0.05 mm wide at its base, which may, or may not, be clearly demarcated from the main chamber. Chamber "ornamented" with about 15

(seven visible from any side) spirally arranged thin ridges. The ridges are about 0.02 mm high, very thin and perforated by a large number of clear radially arranged pores. The ridges twist through about 90° from the neck to the basal pole of the chamber and are present on the neck.

Remarks

This species is named from only two specimens, of which only one (the holotype) was measured for the above description. The only close species are *L. spiralis* Brady, *L. spiralis* Brady var. *cubensis* Palmer and Bermudez, *L. torsicostata* Copeland and *L. tortilis* Egger. *L. spiralis* is most similar but has too few (about 10) spiral ridges. However, the ridges are perforate and rotate through about 90° so the two species seem closely related. *L. spiralis cubensis* differs in having a much more elongate, narrow neck and clear perforations in the chamber wall between the spiral ridges. *L. tortilis* has too many ridges, they are not distinct enough and they twist through something like 180°. The species is also relatively more elongate than this new species. *L. torsicostata* probably has too many ridges (12-24, average 20) and lacks the coarse perforations in the ridges.

Occurrence - (a) Fossil Bluff - 84011 (v) (holotype),
(b) Cape Grim - 84006 (v) (paratype).

Age - Early Miocene, N4/5.

Maximum diameter of holotype 0.25 mm.

Repository - (a) Holotype U.T.G.D. 84209,
(b) Paratype U.T.G.D. 84208.

Lagena sp A

(Pl. 3, fig. 108)

Lagena sp. nov. Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 117, pl. 57, fig. 31.

Occurrence - (a) King Island - 84083 (v), 84086 (r),
(b) Cape Grim - 84006 (v), 84001 (v),
(c) Redpa - 84097 (v), 84096 (v),
(d) Marrawah district - 84113 (c).

Age - Early Miocene, N4-8.

Figured specimen from Cape Grim (84001).

Maximum diameter of figured specimen 0.26 mm.

Repository - U.T.G.D. 84210.

Lagena sp B.

(Pl. e, fig. 109)

Occurrence - (a) Fossil Bluff - 84012 (v),
(b) Marrawah district - 84107 (v).

Age - Early Miocene, N4/5, N8.

Figured specimen from Fossil Bluff.

Maximum diameter of figured specimen 0.17 mm.

Repository - U.T.G.D. 84211.

Lagena spp indet.

Occurrence - (a) Fossil Bluff - 84010a (v),
(b) King Island - 84477 (q),
(c) Redpa - 84094 (r).

Age - Early Miocene.

Genus *LENTICULINA* Lamarck, 1804

Lenticulina cf *chambersi* (Garrett), 1939
(Pl. 3, fig. 110)

Robulus chambersi Garrett, 1939, *J. Paleont.*, 13, 576, pl. 65, figs. 8,9.

Remarks
A single specimen very similar to this species was recovered from King Island (84082). It agrees with *L. chambersi* in having slightly elevated straight sutures, and only few chambers per whorl. However it does not seem to have the sharp keel of *L. chambersi* and is thus a little different.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.80 mm.

Repository - U.T.G.D. 84212.

Lenticulina cultrata (de Montfort), 1808
(Pl. 4, fig. 111)

Robulus cultratus de Montfort, 1808, *Conchyliologie Systematique* ...., F. Schoell: Paris, 2, 215, fig. (p. 214).

Cristellaria cultrata, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 10.

Cristellaria cultrata, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 351.

Cristellaria cultrata, Chapman and Parr, 1926, *Jl. Linn. Soc.*, 36, 390, pl. 21, fig. 68.

Lenticulina cultrata, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 81.

Robulus cultratus, Hornibrook, 1961, *Paleont. Bull.*, Wellington, 34, (1), 38, pl. 4, fig. 62.

Robulus cultratus, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 67.

Remarks
This species is not identified from de Montfort's own figure (*op. cit.*, *fide* Ellis and Messina) but by comparison with various other figures (e.g. Stache, 1865; Chapman, 1926 etc.) and the identification depends on their accuracy. It is the most common species

of *Lenticulina* in the Tasmanian Tertiary.

Occurrence - (a) Mussel Roe Bay - 84483 (v), 84482 (v),
(b) Fossil Bluff - 84010a (v), 84011 (v), 84015 (r), 84019 (r), 84025a (v), 84024 (r), 84025b (v),
(c) Cape Grim - 84006 (v), 84003 (v),
(d) Mt Cameron West - 84121 (v), 84120 (v), 84117 (r),
(e) Brittons Swamp - 84480 (v),
(f) Redpa - 84093 (v),
(g) Marrawah district - 84092 (r), 84108 (r), 84110 (r), 84113 (q), 84114 (r), 84104 (r), 84101 (r), 84105 (r), 84016 (r), 84107 (r).

Age - Late Oligocene - Early Miocene, N3-8.

Figured specimen from Fossil Bluff (84109).

Maximum diameter of figured specimen 0.50 mm.

Repository - U.T.G.D. 84213.

Lenticulina gibba (d'Orbigny), 1839
(Pl. 4, fig. 112)

Cristellaria gibba d'Orbigny, (*in* de la Sagra, 1839), *Histoire physique, politique et naturelle de l'île de Cuba*, A. Bertrand: Paris, 40, 8, pl. 7, figs. 20, 21.

Cristellaria gibba, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), 160.

Cristellaria gibba, Chapman and Parr, 1926, *Jl. Linn. Soc.*, 36, 388, pl. 20, fig. 61.

Lenticulina gibba, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 81.

Occurrence - Mussel Roe Bay - 84483 (r).

Age - Late Oligocene - Early Miocene, N3-5.

Maximum diameter of figured specimen 0.65 mm.

Repository - U.T.G.D. 84400.

Lenticulina gyroscalpra (Stache), 1865
(Pl. 4, fig. 113)

? *Cristellaria intermedia* d'Orbigny var. *whaingeroica* Stache, 1865, *"Novara Expedn, Geol. Theil*, 1, 242, pl. 23, figs. 21a, b.

Cristellaria gyroscalprum Stache, 1865, *ibid.*, 245, pl. 23, figs. 22a, b.

Robulina foliata Stache, 1865, *ibid.*, 245, pl. 23, figs. 24a, b.

Cristellaria gyroscalprum, Chapman, 1926, *Palaeont. Bull.*, Wellington, 11, 62, pl. 4, figs. 21, 22, 24.

Lenticulina gyroscalprum, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 81.

Robulus gyroscalprus, Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 36, pl. 5, fig. 67.

Robulus gyroscalprus, Reed, 1965, *Bull. Am. Paleont.* 49 (220), 67.

Robulus gyroscalprus, Hornibrook, 1971, *Palaeont. Bull.*, Wellington, 43, 43, pl. 9 figs. 160, 161.

Occurrence - (a) Mussel Roe Bay - 84483 (v), 84481 (r),
(b) Fossil Bluff - 84010b (v), 84011 (v), 84014 (r),
(c) Mt Cameron West - 84118 (v),
(d) Brittons Swamp - 84480 (r).

Age - Late Oligocene - Early Miocene, N3-N8.

Figured specimen from Fossil Bluff (84011).

Maximum diameter of figured specimen 0.26 mm.

Repository - U.T.G.D. 84214.

Lenticulina oblonga (Coryell and Rivero), 1940
(Pl. 4, fig. 119)

Robulus oblongus Coryell and Rivero, 1940, *J. Paleont.*, 14, 332, pl. 43, figs. 12a, b.

Remarks
Differs from typical *L. oblonga* in not having a sharply carinate periphery. However, number of chambers, characters of sutures, lack of an umbilical boss and straight periphery to each chamber suggest that this species probably fits well within the variation of *L. oblonga*.

Occurrence - (a) Mussel Roe Bay - 84483 (r),
(b) Cape Grim - 84008 (v), 84006 (v).

Age - Late Oligocene - Early Miocene, N3-N5.

Figured specimen from Cape Grim (84006).

Maximum diameter of figured specimen 0.55 mm.

Repository - U.T.G.D. 84215.

Lenticulina punctata (Rzehak), 1895
(Pl. 4, fig. 114)

Cristellaria punctata Rzehak, 1891, *Annln naturh. Mus.*, Wien, 6 (1), 3.

Cristellariopsis punctata, Rzehak, 1895, *ibid.*, 10, 227, pl. 6, fig. 12.

Occurrence - Fossil Bluff - 84011 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.38 mm.

Repository - U.T.G.D. 84216.

Lenticulina (?) triangularis (d'Orbigny), 1840

(Pl. 4, figs. 115, 116)

Cristellaria triangularis d'Orbigny, 1840, *Mem. Soc. geol. Fr.*, 4, 27, pl. 2, figs. 21, 22.

Remarks
A single very well preserved specimen from Fossil Bluff (84011) is questionably assigned to *L. triangularis*. Another similar species is *L. brachyspira* Reuss.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.39 mm.

Repository - U.T.G.D. 84217.

Lenticulina sp.

(Pl. 4, figs. 117, 118)

Remarks
A single incomplete specimen of a slightly asymmetrical *Lenticulina* was found at Cape Grim (84006). While no positive identification is possible, the species does resemble *L. reniformis* (d'Orbigny), or some such species.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.40 mm.

Repository - U.T.G.D. 84218.

Genus *MARGINULINOPSIS* Silvestri, 1904

Marginulinopsis hydropica Hornibrook, 1961

(Pl. 4, fig. 120)

Marginulinopsis hydropica Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 43, pl. 5, figs. 74, 75, 79, 80.

Remarks
The two specimens found here agree very well with Hornibrook's figures and descriptions of the species. It is found here in rocks of Late Oligocene age (Janjukian) whereas, in New Zealand the species is a little older.

Occurrence - Mussel Roe Bay - 84483 (v).

Age - Early Miocene N4/5.

Maximum diameter of figured specimen 1.05 mm.

Repository - U.T.G.D. 84402

Genus *NODOSARIA* Lamarck, 1812

Nodosaria grossecostata Costa var. a, 1856

(Pl. 4, fig. 121)

Nodosaria grossecostata var. *a* Costa, 1856, *Atti R. Accad. pontan.*, 7 (2), 148, pl. 12, fig. 2.

Remarks

A single specimen showing a bulbous final chamber, and broken, cylindrical earlier parts of the test, was found in each of 3 samples. They appear identical with Costa's type figure of his variety a.

Occurrence - (a) Mussel Roe Bay - 84482 (v),
(b) Redpa - 84095 (v),
(c) Marrawah district - 84113 (v), 84105 (v).

Age - Early Miocene, N4-N8.

Figured specimen from 84113.

Maximum diameter of figured specimen 2.6 mm.

Repository - U.T.G.D. 84192.

Nodosaria hochstetteri Schwager, 1865

(Pl. 4, fig. 122)

Nodosaria hochstetteri Schwager, 1865, *"Novara" Expedn, Geol. Theil.*, 2 (2), 214, pl. 5, fig. 32.

Nodosaria hochstetteri, Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 47, pl. 6, fig. 91.

Occurrence - Fossil Bluff - 84011 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 2.75 mm.

Repository - U.T.G.D. 84536.

Nodosaria lamnulifera Boomgaart, 1950

(Pl. 4, fig. 123)

Nodosaria bradyi Boomgaart, 1949, *Geogr. geol. Meded.*, 79, pl. 6, fig. 11.

Nodosaria lamnulifera Thalmann, 1950, *Contr. Cushman Fdn foramin. Res.*, 1, 42.

Nodosaria lamnulifera, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 134, pl. 64, figs. 6-10.

Remarks

Two fragmentary specimens have been identified by reference to Barker (1960).

Occurrence - Fossil Bluff - 84011 (v), 84017 (r).

Age - Early Miocene, N4/5.

Figured specimen from 84011.

Maximum diameter of figured specimen 0.65 mm.

Repository - U.T.G.D. 84191.

Nodosaria proxima Silvestri, 1872

(Pl. 4, fig. 124)

Nodosaria proxima Silvestri, 1872, *Atti Accad. gioenia Sci. nat.*, ser. 3, 1, 63, pl. 6, figs. 138-147.

Nodosaria proxima, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924) pt. 2, 153.

Remarks

A single well preserved specimen from Marrawah (84107) is referred to this species. It is very similar to Silvestri's *(op. cit.)* fig. 138 which shows a specimen with spiral costae. Another similar species is *N. contorta* Hantken.

Age - Early Miocene, N8.

Maximum diameter of figured specimen 0.48 mm.

Repository - U.T.G.D. 84193.

Nodosaria separans Brady, 1884

(Pl. 4, fig. 125)

Nodosaria scalaris, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 510, pl. 63, figs. 28-31.

Nodosaria scalaris var. *separans* Brady, 1884, *ibid.*, 511, pl. 64, figs. 16-19.

Nodosaria scalaris (Batsch) var. *bilocularis* Rhumbler, 1911, *Ergeb. Plankton Expedn Humboldt-Stiftung*, 3 (1), pl. 20, figs. 12-16.

Amphicoryna scalaris, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 136, pl. 63, figs. 28-31.

Amphicoryna separans, Barker, 1960, *ibid.*, 138, pl. 64, figs. 16-19.

Remarks

There seems to be no valid reason for separating this species from *Lagenonodosaria separans* Brady, but as *Amphicoryna* has priority, the species becomes *A. separans* (Brady). Silvestri (1902) has shown that *Amphicoryna*, being the microspheric form of some *Nodosaria* species, is biologically invalid. Hence the species is here regarded as a species of *Nodosaria*. It is doubtfully separable from *N. scalaris* (Batsch). In all specimens seen there are only two or three chambers.

Occurrence - (a) Fossil Bluff - 84024 (v), 84025b (v),

(b) Brittons Swamp - 84480 (v),

(c) Marrawah district - 84104 (v).

Age - Early Miocene, N4-N8.

Figured specimen from Brittons Swamp (84480).

Maximum diameter of figured specimen 0.62 mm.

Repository - U.T.G.D. 84487.

Nodosaria spp. indet.

Remarks

Only unidentifiable fragments are included under this heading.

Occurrence - (a) Fossil Bluff - 84011 (v),
(b) Mt Cameron West - 84121 (v), 84117 (v),
(c) Redpa - 84095 (v),
(d) Marrawah district - 84092 (v), 84113 (r), 84105 (v).

Age - Early Miocene.

Genus *VAGINULINA* d'Orbigny, 1826

Vaginulina sp.

Remarks

Two very poorly preserved specimens from Marrawah (84111) and one from Brittons Swamp (84480) are placed in this genus. None is figured.

Age - Early Miocene, N8.

Subfamily PLECTOFRONDICULARIINAE

Genus *BOLIVINELLA* Cushman, 1927

Bolivinella australis Cushman, 1929

(Pl. 4, fig. 126)

Textularia folium, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924) pt. 2, 135.

Bolivinella folia, Cushman, 1927, *Contr. Cushman Lab. foramin. Res.* 2 (4), 79.

Bolivinella australis Cushman, 1929, *Contr. Cushman Lab. foramin. Res.*, 5 (2), 32, pl. 5, figs. 6, 7.

Bolivinella folia, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 77.

Occurrence - (a) Fossil Bluff - 84010a (v),
(b) Cape Grim - 84005 (r), 84001 (v).

Age - Early Miocene, N4/5.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 0.35 mm.

Repository - U.T.G.D. 84219.

Family POLYMORPHINIDAE

Subfamily POLYMORPHININAE

Genus *GLOBULINA* d'Orbigny, 1839

Globulina gibba (d'Orbigny), 1826
(Pl. 4, fig. 127)

Polymorphina (Globuline) gibba d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 266.

Polymorphina gibba, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 10.

Polymorphina gibba, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 351.

Polymorphina gibba, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 162.

Polymorphina gibba, Chapman and Parr, 1926, *J. Linn. Soc.*, 36, 391, pl. 21, fig. 71.

Globulina gibba, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Globulina gibba, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 68.

Occurrence - Fossil Bluff - 84010a (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.80 mm.

Repository - U.T.G.D. 84220.

Genus *GUTTULINA* d'Orbigny, 1839

Guttulina communis (d'Orbigny), 1826
(Pl. 4, figs. 128, 129)

Polymorphina (Guttulina) communis d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 26.

Guttulina problema Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50, 191, pl. 12, fig. 1.

Remarks
A very widespread, but usually rare species, it is one of the few species of foraminifera previously recorded from Fossil Bluff (Parr and Collins, 1937, p. 191).

Occurrence - (a) Mussel Roe Bay - 84483 (r), 84481 (q), 84482 (q),
(b) Fossil Bluff - 84010a (q), 84010b (r), 84012 (v), 84013 (r), 84022 (q), 84023 (r), 84025a (r), 84024 (v), 84025b (q).
(c) King Island - 84084 (v), 84085 (v), 84082 (r), 84089 (p),
(d) Cape Grim - 84008 (r), 84007 (r), 84005 (r), 84001 (v),
(e) Mt Cameron West - 84118 (r), 84121 (v), 84120 (v), 84117 (r),
(f) Brittons Swamp - 84480 (r),
(g) Redpa - 84097 (v), 84093 (q), 84094 (r), 84095 (r), 84096 (r),

(h) Granville Harbour - 54144 (q),

(i) Preservation Island - 84479 (r),

(j) Marrawah district - 84092 (r), 84108 (r), 84109 (q), 84110 (q), 84111 (q), 84113 (r), 84114 (v), 84115 (v), 84104 (r), 84101 (r), 84105 (q), 84106 (q), 84107 (q).

Age - Late Oligocene - Early Miocene, N3-N8.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 0.70 mm.

Repository - U.T.G.D. 84221.

Guttulina frankei Cushman and Ozawa, 1930

(Pl. 4, fig. 130)

Polymorphina lactea var. *cuspidata* Franke, 1925, *Abh. Ber. Mus. Nat. u. Heimatk. (Naturk. Vorgesch.) Madgeburg* (1925), 177, pl. 6, fig. 46b.

Guttulina frankei Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 28, pl. 4, figs. 1a-c.

Remarks

In a few samples, typical specimens are found. The figured specimen is a little atypical in having a single distinct ridge on the distal part of several chambers.

Occurrence - (a) Mussel Roe Bay - 84482 (r),

(b) Fossil Bluff - 84010b (v), 84022 (v), 84024 (v),

(c) Redpa - 84093 (v).

Age - Early Miocene, N4-N8.

Figured specimen from Fossil Bluff (84010b).

Maximum diameter of figured specimen 0.92 mm.

Repository - U.T.G.D. 84222.

Guttulina lactea (Walker and Jacob), 1798

(Pl. 4, fig. 131)

Serpula tenuis ovalis laevis Walker and Boys, 1784, *Testacea minuta ....*, J. March: London, 2, pl. 1, fig. 5.

Serpula lactea Walker and Jacob, 1798, *Adams' essays on the microscope*, Dillon and Keating: London, 2nd Edn., 634, pl. 14, fig. 4.

Polymorphina lactea, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 10.

Polymorphina lactea, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 352.

Polymorphina lactea, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 161.

Guttulina lactea, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 43, 44, pl. 10, figs. 1-4.

Guttulina lactea, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Occurrence - (a) Fossil Bluff - 84010b (r), 84022 (v),
(b) Cape Grim - 84006 (v).

Age - Early Miocene, N4/5.

Figured specimen from Fossil Bluff (84010b).

Maximum diameter of figured specimen 0.92 mm.

Repository - U.T.G.D. 84223.

Guttulina regina (Brady, Parker and Jones), 1870
(Pl. 4, figs. 132-134)

Polymorphina regina Brady, Parker and Jones, 1870, *Trans. Linn. Soc. Lond.*, 27, 241, pl. 41, figs. 32a, b.

Polymorphina regina, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 10.

Polymorphina regina, Howchin, 1891, *ibid.*, 14, 351.

Guttulina regina, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 34, pl. 6, figs. 1, 2.

Guttulina regina, Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50 (1), 192, pl. 12, figs. 6, 7.

Guttulina regina, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Remarks

This species is here recorded as two separate forms. Form 'a': this form is represented by a single specimen from Fossil Bluff and is probably only a costate form of *G. communis*. Form 'b': this form has more elongate and more strongly costate chambers, and occurs in two Mussel Roe Bay samples (84481 and 84482).

Occurrence - Form 'a' Fossil Bluff - 84024 (v),
Form 'b' Mussel Roe Bay - 84481 (r), 84482 (r).

Age - Early Miocene, N4/5.

Figured specimen from (a) Fossil Bluff (84024),
(b) Mussel Roe Bay (84481).

Maximum diameters of figured specimens (a) 0.46 mm,
(b) 0.96 mm.

Repository - (a) U.T.G.D. 84244,
(b) U.T.G.D. 84489.

Guttulina (?) schafferi Cushman and Ozawa, 1930

(Pl. 4, fig. 135)

Guttulina schafferi Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 45, pl. 11, figs. 1a-c.

Remarks

Two poorly preserved hispid specimens from King Island (84090) are referred very tentatively to this species.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.62 mm.

Repository - U.T.G.D. 84490.

Guttulina yabei Cushman and Ozawa, 1929

(Pl. 4, fig. 136)

Polymorphina oblonga, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 569, pl. 73, figs. 2, 3.

Guttulina yabei Cushman and Ozawa, 1929, *Jap. J. Geol. Geogr.*, 6, 68, pl. 13, fig. 2; pl. 14, fig. 6.

Guttulina yabei, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 30, 41, pl. 4, figs. 6, 7.

Guttulina yabei, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Guttulina yabei, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 68.

Occurrence - King Island - 84086 (r).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.75 mm.

Repository - U.T.G.D. 84225.

Guttulina sp. indet.

Occurrence - Fossil Bluff - 84014 (v).

Age - Early Miocene, N4/5.

Genus *PSEUDOPOLYMORPHINA* Cushman and Ozawa, 1928

Pseudopolymorphina beaumarisensis Parr and Collins, 1937

(Pl. 4, fig. 137)

Pseudopolymorphina doanei (Galloway and Wissler) var. *beaumarisensis* Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50 (1), 200, pl. 14, fig. 3.

Pseudopolymorphina doanei var. *beaumarisensis* Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 82.

Remarks
Two specimens were recovered from Fossil Bluff. One complete, typical specimen (from 84010b) is figured. The other (from 84024) is broken and is atypical in having much coarser ribs than the former. A single specimen was recovered from Preservation Island (84479, v).

Age - Early Miocene, N4-N8.

Maximum diameter of figured specimen 1.15 mm.

Repository - U.T.G.D. 84226.

Pseudopolymorphina subcylindrica (Hantken), 1876
(Pl. 4, fig. 138)

Polymorphina subcylindrica, Hantken, 1876, *Magy. allami földt. Intez. Evk.*, 4, 51, pl. 14, fig. 14.

Pseudopolymorphina subcylindrica, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 107, pl. 28, figs. 2a-c.

Remarks
This species differs from *P. tasmanica*, mainly in having less obvious sutures because the chambers are much less inflated than those in *P. tasmanica*. Two very well preserved specimens were recovered.

Occurrence - Fossil Bluff - 84024 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 1.07 mm.

Repository - U.T.G.D. 84227.

Pseudopolymorphina tasmanica Parr and Collins, 1937
(Pl. 4, fig. 139)

Pseudopolymorphina tasmanica Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50, 200, pl. 14, figs. 6a-c.

Remarks
A single, partly broken topotype was found at Fossil Bluff (84010a).

Age - Early Miocene, N4/5.

Maximum diameter of figured topotype 1.48 mm.

Repository - U.T.G.D. 84228.

Genus *PYRULINA* d'Orbigny, 1826

Pyrulina fusiformis (Roemer), 1838

(Pl. 4, fig. 140)

Polymorphina fusiformis Roemer, 1838, *Neues Jb. Miner. Geol. Paläont.*, (1838), 386, pl. 3, fig. 37.

Polymorphina angusta, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 563, pl. 72, figs. 1-3.

Pyrulina fusiformis, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 54, pl. 13, figs. 3-8.

Pyrulina fusiformis, Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50 (1), 197, pl. 13, figs. 2, 3; pl. 14, fig. 5.

Pyrulina fusiformis, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 82.

Pyrulina fusiformis, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 68.

Remarks

In common with many polymorphinids, this was recorded by Parr and Collins (*op. cit.*).

Occurrence - (a) Mussel Roe Bay - 84482 (r),
(b) Fossil Bluff - 84010b (v), 84025b (v).

Age - Early Miocene, N4/5.

Figured specimen from Fossil Bluff (84010b).

Maximum diameter of figured specimen 0.55 mm.

Repository - U.T.G.D. 84230.

Pyrulina gutta d'Orbigny, 1826

(Pl. 4, fig. 141)

Pyrulina gutta d'Orbigny, 1826, *Annls Sci. nat.*, 7, 267, no. 28.

Polymorphina lactea Brady, 1884, *"Challenger" Expedn. Scient. Results, Zool.*, 9, 559, pl. 71, fig. 14.

Remarks

This appears to be the only reference to this species from Australia. The specimen from Mussel Roe Bay (84483) is identified mainly by comparison with Brady's (1884) figure of *Polymorphina lactea* (= *Pyrulina gutta* of Barker, 1960).

Occurrence - Mussel Roe Bay - 84483 (v).

Age - Late Oligocene, N3.

Maximum diameter of figured specimen 0.80 mm.

Repository - U.T.G.D. 84439.

Genus *SIGMOIDELLA* Cushman and Ozawa, 1928

Sigmoidella elegantissima (Parker and Jones), 1865

(Pl. 4, fig. 142)

Polymorphina elegantissima Parker and Jones, 1865, *Phil. Trans. R. Soc.*, 155, 438.

Polymorphina elegantissima, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 10.

Polymorphina elegantissima, Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 352.

Polymorphina elegantissima, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), 162.

Polymorphina elegantissima, Chapman and Parr, 1926, *Jl Linn. Soc.*, 36, 392, pl. 21, fig. 77.

Sigmoidella elegantissima, Cushman and Ozawa, 1929, *Jap. Jl Geol Geogr.*, 6, 76, pl 16, figs. 10, 11.

Sigmoidella elegantissima, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 140, 141, pl. 39, figs. 1a-c.

Sigmoidella elegantissima, Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50, 206, pl. 14, fig. 9.

Sigmoidella elegantissima, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.

Sigmoidella elegantissima, Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 19.

Sigmoidella elegantissima, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 68, pl. 12, fig. 6.

Remarks

Considering the large size, and the fact that it is more abundant than many of the polymorphinids reported from Fossil Bluff, it is very surprising that this species was not recorded from this locality by Parr and Collins (1937, *op. cit.*). It is quite clear that they cannot have confused it with any of the species they did record and it seems most likely to me that the omission is due to an editorial slip rather than lack of identification.

Occurrence - (a) Mussel Roe Bay - 84483 (r), 84481 (v), 84482 (q),

(b) Fossil Bluff - 84010a (v), 84010b (r), 84011 (v), 84012 (v), 84013 (v), 84025a (v).

(c) Mt Cameron West - 84118 (r), 84121 (r), 84117 (r),

(d) Preservation Island - 84479 (r),

(e) Brittons Swamp - 84480 (v),

(f) Marrawah district - 84092 (r), 84108 (q), 84109 (r), 84110 (v), 84111 (r), 84114 (v), 84105 (r), 84106 (q), 84107 (r).

Age - Late Oligocene - Early Miocene, N3-N8.

Figured specimen from Fossil Bluff (84010a).

Maximum diameter of figured specimen 1.10 mm.

Repository - U.T.G.D. 87231

Genus *SIGMOMORPHINA* Cushman and Ozawa, 1928

Sigmomorphina chapmani (Heron-Allen and Earland), 1924

(Pl. 4, fig. 143)

Polymorphina chapmani Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), 163, pl. 10, figs. 60-63.

Sigmomorphina chapmani, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 124, pl. 32, figs. 4, 5.

Sigmomorphina chapmani, Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50 (1), 204, pl. 15, figs. 2a-c.

Sigmomorphina chapmani, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.

Sigmomorphina chapmani, Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 68, pl. 12, fig. 3.

Occurrence - Mussel Roe Bay - 84483 (v).

Age - Late Oligocene, N3.

Maximum diameter of figured specimen 1.0 mm.

Repository - U.T.G.D. 84452.

Sigmomorphina schwageri (Karrer), 1877

(Pl. 4, fig. 144)

Polymorphina schwageri Karrer, 1877, *Abh. geol. Bundesanst.*, Wien, 9, 384, pl. 166, fig. 43.

Sigmomorphina schwageri, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 130, pl. 34, figs. 1a-c.

Sigmomorphina cf *schwageri*, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.

Remarks

The specimens are also very similar to Parr and Collins' (1937) figures of *Polymorphina lingulata* Stache.

Occurrence - Mussel Roe Bay - 84483 (v).

Age - Late Oligocene, N3.

Maximum diameter of figured specimen 2.15 mm.

Repository - U.T.G.D. 84453.

Sigmomorphina semitecta (Reuss), 1867

(Pl. 4, fig. 145)

Polymorphina semitecta Reuss, 1867, *Sber, Akad. Wiss.* Wien, 55 (1), 91, pl 3, fig. 10.

Sigmomorphina semitecta, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 129, pl. 33, figs. 6, 7.

Remarks
This species, apparently unrecorded from the Australian Tertiary, is represented by a single well preserved specimen in the Fossil Bluff section (84010b). While Cushman and Ozawa (1930) state that the species is broadly rounded at the base, their figures show it to be quite noticeably attenuated and this is the condition of the specimen recovered.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.36 mm.

Repository - U.T.G.D. 84232.

Sigmomorphina williamsoni (Terquem), 1878

(Pl. 4, fig. 146)

Polymorphina williamsoni Terquem, 1878, *Mem. Soc. geol. Fr.*, ser. 3, 1, 37.

? Polymorphina lactea var. *oblonga*, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 10.

Sigmomorphina williamsoni, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 138, pl. 38, figs. 3, 4.

Sigmomorphina williamsoni, Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50, 205, pl. 15, fig. 5.

Sigmomorphina williamsoni, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.

Occurrence - (a) Marrawah district - 84092 (v),
(b) Brittons Swamp - 84480 (v).

Age - Early Miocene, N4-N8.

Figured specimen from Marrawah.

Maximum diameter of figured specimen 0.42 mm.

Repository - U.T.G.D. 84233.

Sigmomorphina wynyardensis Parr and Collins, 1937

(Pl. 4, figs. 147, 148)

Sigmomorphina wynyardensis Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50, 203, pl. 15, fig. 3a-c.

Remarks
A few topotypes were recovered from Fossil Bluff (84010a (v)) and a poorly preserved specimen from Redpa (84093 (v)).

Age - Early Miocene, N4-N8.

Figured topotype from 84010a.

Maximum diameter of figured topotype 1.56 mm.

Repository - U.T.G.D. 84234.

Family GLANDULINIDAE

Subfamily GLANDULININAE

Genus *GLANDULINA* d'Orbigny, 1826

Glandulina laevigata d'Orbigny, 1826
(Pl. 4, fig. 149)

Nodosaria (Glandulina) laevigata d'Orbigny, 1826, *Annls Sci. nat.*, ser. 1, 7, 252, pl. 10, figs. 1-3.

Glandulina laevigata d'Orbigny, 1846, *Foraminiferes fossiles du Bassin Tertaire de Vienne (Autriche)*, Gide and Co.: Paris, 29, pl. 1, figs. 4, 5.

Nodosaria laevigata, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), 152.

Nodosaria (Glandulina) laevigata, Chapman and Parr, 1926, *Jl Linn. Soc.*, 36, 378, pl. 17, fig. 20.

Glandulina laevigata, Cushman and Ozawa, 1930, *Proc. U.S. natn. Mus.*, 77, art. 6, 143, pl. 40, figs. 1a, b.

Glandulina laevigata, Parr and Collins, 1937, *Proc. R. Soc. Vict.*, n.s. 50, 208, pl. 13, figs. 6a, c.

Glandulina laevigata, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 79.

Glandulina laevigata, Reed, 1965, *Bull. Am. Paleont.*, 49, (220), 68.

Remarks

All specimens found here are relatively more elongate than the figured specimens of Cushman and Ozawa (1930) and Parr and Collins (1937), but fit within the variation range of d'Orbigny's figures.

Occurrence - (a) Fossil Bluff - 84010a (r), 84011 (v), 84014 (v),
(b) Mt Cameron West - 84120 (v).

Age - Early Miocene, N4/5.

Figured specimen from 84010a.

Maximum diameter of figured specimen 0.56 mm.

Repository - U.T.G.D. 84229.

Subfamily OOLININAE

Genus *FISSURINA* Reuss, 1850

Fissurina annectens (Burrows and Holland), 1895
(Pl. 4, fig. 150)

Lagena annectens Burrows and Holland, *in* Jones, 1895, *Palaeontogr. Soc. Monogr.*, (1895), 203, pl. 7, fig. 11.

Lagena annectens, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 151.

Lagena annectens, Chapman and Parr, 1926, *Jl Linn. Soc.*, 36, 376, pl. 17, fig. 11.

Remarks
Although in the single specimen recovered (Cape Grim, 84006) the surface sulci are very poorly visible, they are present.

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.30 mm.

Repository - U.T.G.D. 84340.

Fissurina circulum Seguenza, 1862
(Pl. 4, fig. 151)

Fissurina circulum Seguenza, 1862, *Die terreni Terziarii del Distretto di Messina: Parte II ...*, T. Capra: Messina, 63, pl. 2, fig. 15.

Occurrence - (a) Mussel Roe Bay - 84483 (r),
(b) Fossil Bluff - 84019 (r).

Age - Late Oligocene - Early Miocene, N3-5.

Figured specimen from Fossil Bluff.

Maximum diameter of figured specimen 0.25 mm.

Repository - U.T.G.D. 84235.

Fissurina cucullata Silvestri, 1902
(Pl. 4, fig. 152)

Fissurina cucullata Silvestri, 1902, *Memorie Accad. pont. Nuovi Lincei*, 19, 146, figs. 23-25.

Occurrence - (a) Mussel Roe Bay - 84483 (v),
(b) Fossil Bluff - 84010b (v), 84012 (v), 84013 (r), 84022 (q), 84025a (v), 84024 (v), 84025b (r),
(c) Mt Cameron West - 84117 (r),
(d) Granville Harbour - 54144 (r).

Age - Late Oligocene - Early Miocene, N3-N8.

Figured specimen from Fossil Bluff (84013)

Maximum diameter of figured specimen 0.25 mm.

Repository - U.T.G.D. 84236.

Fissurina laevigata Reuss, 1850

Fissurina laevigata Reuss, 1850, *Denkschr. Akad. Wiss. Wien*, 1, 366, pl. 46, fig. 1.

Remarks A single broken, silicified specimen was recovered from the Granville Harbour deposit (54144) and is not figured.

Age - Early Miocene, N8.

Repository - U.T.G.D. 84341.

Fissurina marginata (Montagu), 1803

(Pl. 4, fig. 153)

Serpula (Lagena) marginata Walker and Boys, 1784, *Testacea minuta...*, J. March: London, 2, pl. 1, fig. 7.

Vermiculum marginatum Montagu, 1803, *Testacea Brittanica...*, J.S. Hollis: Romsey, England, 524.

Occurrence - Granville Harbour - 54144 (r).

Age - Early Miocene, N8.

Maximum diameter of figured specimen 0.23 mm.

Repository - U.T.G.D. 84342.

Fissurina cf *quadrata* (Williamson), 1858

(Pl. 4, fig. 154)

Entosolenia marginata (Montagu) var. *quadrata* Williamson, 1858, *Ray Soc. Publs*, (1858), 11, pl. 1, figs. 27-28.

Lagena quadrata, Chapman and Parr, 1926, *Jl Linn. Soc.*, 36, pl. 17, fig. 16.

Remarks A few specimens of an elongate species, probably *F. quadrata* are included here.

Occurrence - (a) Fossil Bluff - 84022 (v), 84025b (v),
(b) Brittons Swamp - 84480 (v),
(c) Marrawah district - 84106 (r).

Age - Early Miocene, N4-N8.

Figured specimen from Fossil Bluff (84025b).

Maximum diameter of figured specimen 0.27 mm.

Repository - U.T.G.D. 84237.

Fissurina siciliensis Loeblich and Tappan, 1954
(Pl. 4, fig. 155)

Fissurina (Fissurine) marginata Seguqnza, 1862, *Die terreni Terziarii del Distretto di Messina: Part II ...*, T. Capra: Messina, 66, pl. 2, figs. 27-28.

Fissurina siciliensis Loeblich and Tappan, 1954, *J. Wash. Acad. Sci.*, 44 (12), 384.

Occurrence - (a) Mussel Roe Bay - 84483 (r),
(b) Fossil Bluff - 84010b (r), 84011 (v), 84012 (r), 84013 (r), 84015 (r), 84017 (r), 84021 (f), 84022 (r), 84025a (v), 84024 (v).
(c) Daisy Creek - 84478 (r),
(d) Marrawah district - 84104 (v).

Age - Late Oligocene, - Early Miocene, N3-N8.

Figured specimen from Fossil Bluff (84013).

Maximum diameter of figured specimen 0.30 mm.

Repository - U.T.G.D. 84238.

Fissurina simplex Seguenza, 1862.
(Pl. 4, fig. 156)

Fissurina (Fissurina) simplex Seguenza, 1862, *Die terreni Terziarii del Distretto di Messina: Part II ...*, T. Capra: Messina, 56, pl. 1, fig. 44.

Remarks
Separated from *F. circulum* mainly in being much more inflated and a little attentuated at the apertural end.

Occurrence - (a) Fossil Bluff - 84010b (v), 84015 (r),
(b) Cape Grim - 84006 (v).

Age - Early Miocene, N4/5.

Figured specimen from Cape Grim (84006).

Maximum diameter of figured specimen 0.34 mm.

Repository - U.T.G.D. 84239

Fissurina spp. indet.

Remarks
Only four specimens are listed here. All seem to belong to different species but identification is very difficult. One is probably *Parafissurina*.

Occurrence - (a) Mussel Roe Bay - 84481 (v),
(b) Fossil Bluff - 84011 (v),
(c) Cape Grim - 84008 (v), 84007 (r).

Age - Early Miocene, N4/5.

Genus *OOLINA* d'Orbigny, 1839

Oolina apiculata Reuss, 1851
(Pl. 4, fig. 157)

Oolina apiculata Reuss, 1851, *Abh. naturw. Wien*, 4 (1), 22, pl. 2, fig. 1.

Lagena apiculata, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 147, pl. 9, fig. 29.

Lagena apiculata, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Occurrence - (a) Fossil Bluff - 84013 (v), 84014 (r), 84015 (r), 84019 (v),
(b) Mt Cameron West - 84117 (v).

Age - Early Miocene, N4/5.

Figured specimen from 84014.

Maximum diameter of figured specimen 0.40 mm.

Repository - U.T.G.D. 84240.

Oolina globosa (Montagu), 1803
(Pl. 4, fig. 158)

Serpula (Lagena) laevis globosa Walker and Boys, 1784, *Testacea minuta ...*, J. March: London, 3, pl. 1, fig. 8.

Vermiculum globosum Montagu, 1803, *Testacea Brittanica ...*, J.S. Hollis: Romsey, England, 523.

Lagena globosa, Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 8.

Lagena globosa, Heron-Allen and Earland, 1924, *Jl R. microsc. Soc.*, (1924), pt. 2, 146.

Lagena globosa, Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Occurrence - (a) Mussel Roe Bay - 84483 (r),
(b) Fossil Bluff - 84011 (v), 84013 (r), 84019 (v), 84025a (v), 84024 (v), 84025b (r),
(c) King Island - 84085 (v), 84081 (v), 84082 (q), 84086 (r), 84477 (q),
(d) Cape Grim - 84006 (v), 84001 (v),
(e) Redpa - 84097 (r), 84093 (v).

Age - Early Miocene, N4-N8.

Figured specimen from Fossil Bluff (84013).

Maximum diameter of figured specimen 0.25 mm.

Repository - U.T.G.D. 84241.

Oolina inornata d'Orbigny, 1839

(Pl. 4, fig. 159)

Oolina inornata d'Orbigny, 1839, *Voyage dans l'Amerique Meridionale; Foraminiferes*, Pitois-Levrault: Paris; V. Levrault: Strasbourg.

Occurrence - Fossil Bluff - 84011 (v).

Age - Early Miocene, N4/5.

Maximum diameter of figured specimen 0.30 mm.

Repository - U.T.G.D. 84242.

Oolina (?) multicosta (Karrer), 1877

(Pl. 4, fig. 160)

? Fissurina multicosta Karrer, 1877, *Abh. geol. Bundesanst. Wien*, 9, 379, pl. 16b, fig. 20.

Lagena multicostata, Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool*, 9, 466, pl. 61, fig. 4.

Oolina multicostata, Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 127, pl. 61, fig. 4.

Remarks

The species found at Mussel Roe Bay (84483) is almost identical with that figured by Brady (1884). It is here regarded as the same species.

However, it is not so clear that it is *Oolina multicostata*. Karrer's (1877) original figure of the species seems much closer to *Oolina variata* (Brady) than to the species figured by Brady and recorded here.

Occurrence - Mussel Roe Bay - 84483 (v).

Age - Late Oligocene, N3.

Maximum diameter of figured specimen 0.32 mm.

Repository - U.T.G.D. 84405.

Genus *PARAFISSURINA* Parr, 1947

Parafissurina sp.

(Pl. 4, fig. 161)

Remarks

A single, well preserved specimen was recovered from Mussel Roe Bay (84483). It appears to be an undescribed species.

Age - Late Oligocene, N3.

Maximum diameter of figured specimen 0.25 mm.

Repository - U.T.G.D. 84407.

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ILLUSTRATIONS OF TASMANIAN TERTIARY FORAMINIFERA

PLATE 1

Figure

1-3 *Cyclammina* cf. *incisa* (Stache), Fossil Bluff. 1, 2. U.T.G.D. 84138, x 20. 3. wall section showing labyrinthine structure. U.T.G.D. 84484, x 60.

4 *Bdelloidina aggregata* Carter, Mussel Roe Bay, U.T.G.D. 84472, x 13.

5,6 *Textularia fixtulosa* Brady, Mussel Roe Bay, U.T.G.D. 84474, x 40. 5. peripheral view; 6. lateral view.

7 *T. gramen* d'Orbigny, Fossil Bluff, U.T.G.D. 84139, x 30.

8,9 *T.* cf. *hayi* Karrer, Cape Grim, U.T.G.D. 84140, x 40. 8. lateral view; 9. apertural view.

10 *T. praelonga* Reuss, Fossil Bluff, U.T.G.D. 84141, x 40.

11 *Semivulvulina capitata* (Stache), Marrawah, U.T.G.D. 84142, x 40.

12 *Siphotextularia* aff. *bolivina* Hornibrook, Mussel Roe Bay, U.T.G.D. 84143, x 40.

13 *Ammosphaeroidina sphaeroidiniformis* (Brady), Marrawah, U.T.G.D. 84144, x 35.

14,15 *Gaudryina convexa* (Karrer), x 35. 14. Redpa, U.T.G.D. 84145; 15. Marrawah, U.T.G.D. 84146.

16,17 *Tritaxia victoriensis* (Cushman), Mt. Cameron West, U.T.G.D. 84147, x 35. 16. lateral view; 17 apertural view.

18,19 *Dorothia parri* Cushman, Fossil Bluff, U.T.G.D. 84148, x 25. 18. apertural view; 19 lateral view.

20,21 *Pseudoclavulina* cf. *anglica* Cushman, Fossil Bluff, U.T.G.D. 84485. 20. apertural view, x 40; 21. Lateral view, x 25.

22 *Cyclogyra involvens* (Reuss), Fossil Bluff, U.T.G.D. 84149, x 45.

23 *Spiroloculina angulata* Cushman, Fossil Bluff, U.T.G.D. 84150, x 35.

24 *S. rotunda* d'Orbigny, Fossil Bluff, U.T.G.D. 84151, x 40.

25 *S.* of *sublimbata* Parr, Cape Grim, U.T.G.D. 84153, x 50.

26 *S. tenuiseptata* Brady, Fossil Bluff, U.T.G.D. 84152, x 25.

27 *S. acutimargo* Brady, Fossil Bluff, U.T.G.D. 84154, x 55.

28-33 *Crenulostomina banksi* n. gen. n. sp., Fossil Bluff. 28,29. Holotype U.T.G.D. 84156, x 29. 30. enlarged view of aperture, Holotype, x 220. 31. enlarged view of chamber surface, Holotype, x 75. 32,33 Paratype U.T.G.D. 84157, x 29.

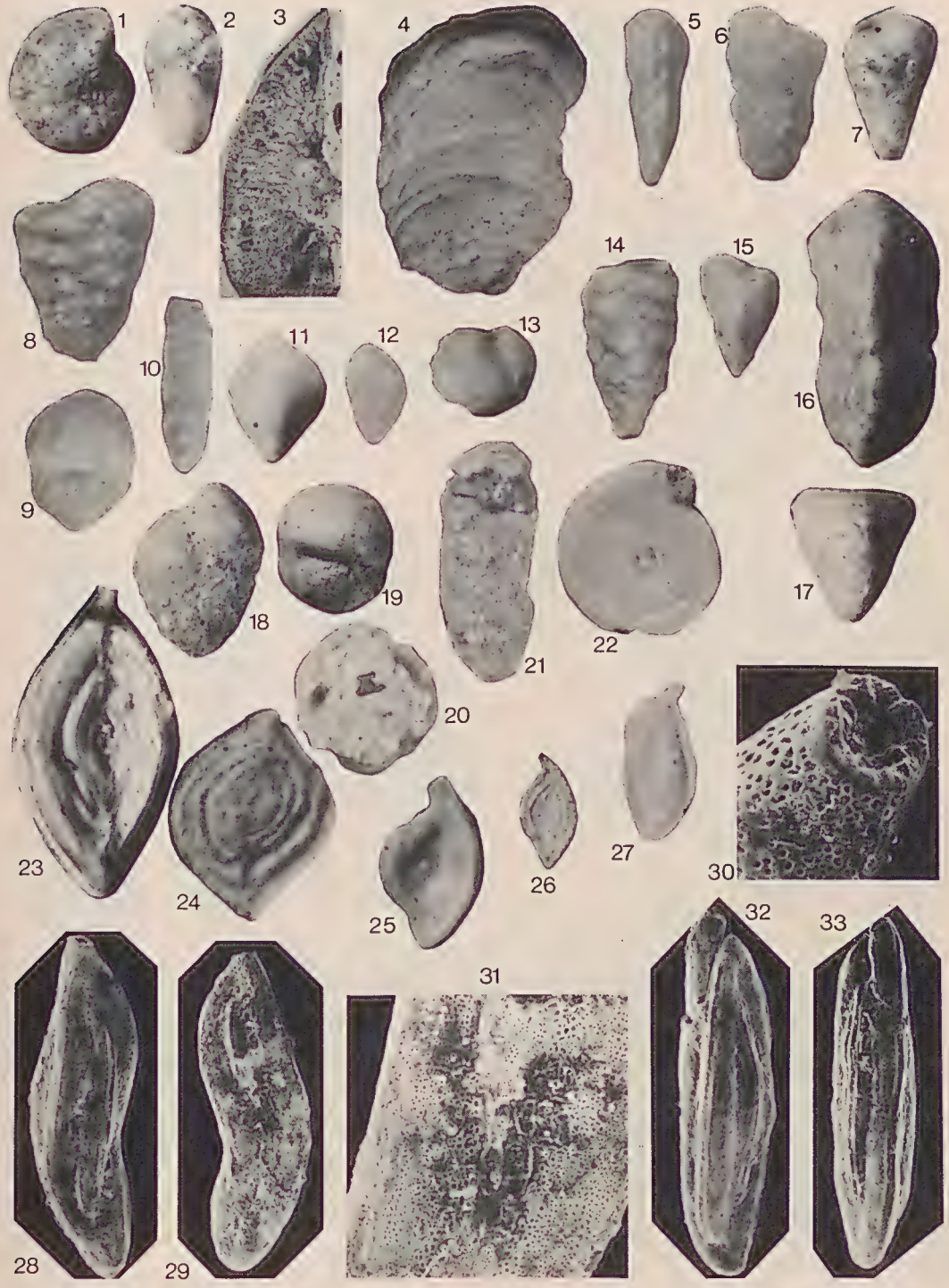
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PLATE 1

PLATE 2

Figure

34,35 *Pyrgo elongata* (d'Orbigny), Cape Grim, U.T.G.D. 84170, x 35.

36 *P. inornata* (d'Orbigny) Marrawah, U.T.G.D. 84171, x 45.

37 *P. sarsi* (Schlumberger), Fossil Bluff, U.T.G.D. 84172, x 35.

38 *P. vespertilio* (Schlumberger), Fossil Bluff, U.T.G.D. 84173, x 40.

39,40 *Quinqueloculina angularis* d'Orbigny, Cape Grim, U.T.G.D. 84159, x 40.

41,42 *Q. angulostriata* Cushman and Valentine, Fossil Bluff, U.T.G.D. 84160, x 40.

43,44 *Q. aspera* d'Orbigny, Fossil Bluff, U.T.G.D. 84161, x 20.

45,46 *Q. bradyana* Cushman, Cape Grim, U.T.G.D. 84162, x 35.

47,48 *Q. cuvieriana* d'Orbigny, Fossil Bluff, U.T.G.D. 84163, x 60.

49,50 *Q. granulosa* Natland, Fossil Bluff, U.T.G.D. 84164, x 45.

51 *Q. laevigata* d'Orbigny, Cape Grim, U.T.G.D. 84165, x 45.

52,53 *Q. seminulum* (Linne), Fossil Bluff, U.T.G.D. 84166, x 45.

54,55 *Q. simplex* Terquem, Fossil Bluff, U.T.G.D. 84167, x 45.

56,57 *Q. vulgaris* d'Orbigny, Fossil Bluff, U.T.G.D. 84168, x 25.

58 *Q.* sp. 1, Cape Grim U.T.G.D. 84169, x 25.

59-61 *Sigmoilina obesa* Heron-Allen and Earland, microspheric form, Fossil Bluff. 59,60. complete, U.T.G.D. 84176, x 45; 61. transverse section, U.T.G.D. 84174, x 60.

62-64 *S. obesa* Heron-Allen and Earland, megalospheric form, Fossil Bluff. 62,63. complete, U.T.G.D. 84177 x 45; 64. transverse section, U.T.G.D. 84175, x 65.

65,66 *S. victoriensis* Cushman, Fossil Bluff, U.T.G.D. 84178, x 50.

67,68 *Siphonaperta ammophila* (Parr), Fossil Bluff, U.T.G.D. 84179, x 45.

69-71 *Spirosigmoilina tateana* (Howchin), Fossil Bluff. 69. microspheric form, U.T.G.D. 84188, x 35; 70,71. megalospheric form, U.T.G.D. 84187, x 70. Shown immersed in Figure 71.

72,73 *Triloculina affinis* d'Orbigny, Cape Grim, U.T.G.D. 84181, x 45.

74,75 *T. brochita* Carter, Fossil Bluff, U.T.G.D. 84182, x 25.

76,77 *T. laevigata* d'Orbigny, Cape Grim, U.T.G.D. 84185, x 45.

78,79 *T. rotunda* d'Orbigny, Cape Grim, U.T.G.D. 84183, x 30.

80,81 *T. trigonula* (Lamarck), Fossil Bluff, U.T.G.D. 84184, x 45.

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PLATE 2

PLATE 3

Figure

82,83 *T.* sp. 1, Cape Grim, U.T.G.D. 84186, x 45.

84,85 *Miliolinella subrotunda* (Montagu), Cape Grim, U.T.G.D. 84180, x 35.

86 *Articulina carinata* Wiesner, Fossil Bluff, U.T.G.D. 84189, x 40.

87 *A.* sp., Fossil Bluff, U.T.G.D. 84190, x 45.

88 *Dentalina divergens* Reuss, Cape Grim, U.T.G.D. 84198, x 12.

89 *D. advena* (Cushman), Cape Grim, U.T.G.D. 84195, x 60.

90 *D. filiformis* (d'Orbigny), Fossil Bluff, U.T.G.D. 84196, x 40.

91 *D. godjeni* Quilty, topotype, Fossil Bluff, U.T.G.D. 84293, x 10.

92 *D. obliqua* (Linné), Mussel Roe Bay, U.T.G.D. 84294, x 7.

93 *D. semirugosa* (d'Orbigny), Fossil Bluff, U.T.G.D. 84197, x 60.

94 *D. subcostata* Chapman, Fossil Bluff, U.T.G.D. 84537, x 9.

95 *D. subsoluta* (Cushman), Mussel Roe Bay, U.T.G.D. 84295, x 16.

96 *Dimorphina* sp. Marrawah, U.T.G.D. 84199, x 60.

97 *Lagena aspera* Reuss, Mussel Roe Bay, U.T.G.D. 84371, x 110.

98 *L. hexagona* (Williamson), Fossil Bluff, U.T.G.D. 84486, x 125.

99 *L. hispida* Reuss, Fossil Bluff, U.T.G.D. 84200, x 110.

100 *L. hispidula* Cushman, Fossil Bluff, U.T.G.D. 84203, x 125.

101,102 *L. laevis* (Montagu), Fossil Bluff. 101. U.T.G.D. 84202, x 110; 102. U.T.G.D. 84201, x 100.

103 *L. mariae* Karrer, King Island, U.T.G.D. 84204, x 70.

104 *L. montagui* Silvestri, Fossil Bluff, U.T.G.D. 84205, x 100.

105 *L. striata* (d'Orbigny), Fossil Bluff, U.T.G.D. 84206, x 90.

106 *L. sulcata* (Walker and Jacob), Fossil Bluff, U.T.G.D. 84207, x 125.

107 *L. tasmaniae* n. sp., Fossil Bluff, Holotype, U.T.G.D. 84209, x 125.

108 *L.* sp. A., Cape Grim, U.T.G.D. 84210, x 125.

109 *L.* sp. B., Fossil Bluff, U.T.G.D. 84211, x 200.

110 *Lenticulina* cf. *chambersi* (Garrett), King Island, U.T.G.D. 84212, x 60.

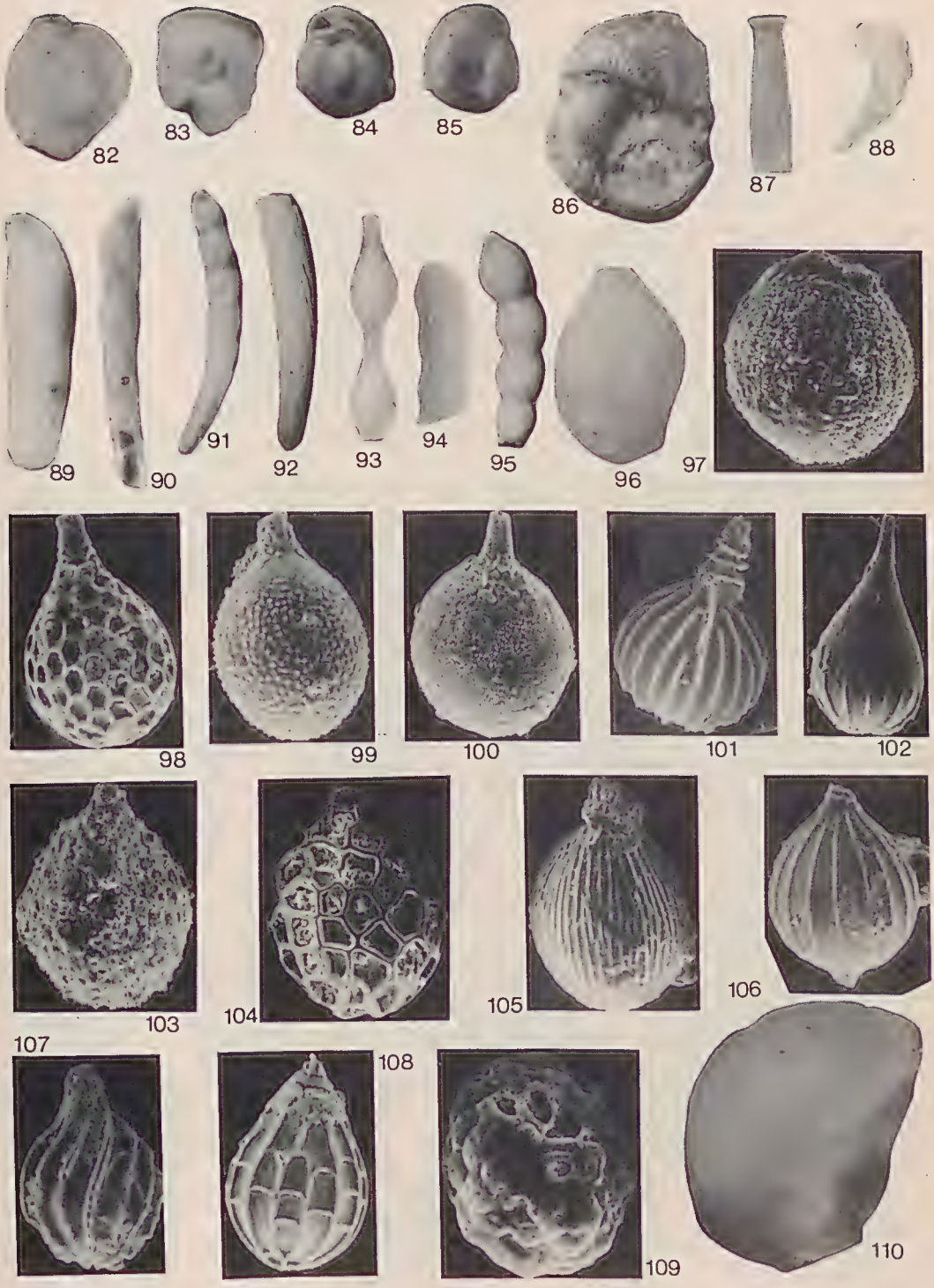
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PLATE 4

Figure

111 *L. cultrata* (de Montfort), Fossil Bluff, U.T.G.D. 84213, x 35.

112 *L. gibba* (d'Orbigny), Mussel Roe Bay, U.T.G.D. 84400, x 60.

113 *L. gyroscalpra* (Stache), Fossil Bluff, U.T.G.D. 84214, x 60.

114 *L. punctata* (Rzehak), Fossil Bluff, U.T.G.D. 84216, x 60.

115,116 *Lenticulina (?) triangularis* (d'Orbigny), Fossil Bluff, U.T.G.D. 84217, x 45.

117,118 *L.* sp., Cape Grim, U.T.G.D. 84218, x 45.

119 *L. oblonga* (Coryell and Rivero), Cape Grim, U.T.G.D. 84215, x 60.

120 *Marginulinopsis hydropica* Hornibrook, Mussel Roe Bay, U.T.G.D. 84402, x 38.

121 *Nodosaria grossecostata* Costa var. a, Marrawah, U.T.G.D. 84192, x 12.

122 *N. hochstetteri* Schwager, Fossil Bluff, U.T.G.D. 84536, x 9.

123 *N. lamnulifera* Boomgaart, Fossil Bluff, U.T.G.D. 84191, x 50.

124 *N. proxima* Silvestri, Marrawah, U.T.G.D. 84193, x 45.

125 *N. separans* Brady, Brittons Swamp, U.T.G.D. 84487, x 40.

126 *Bolivinella australis* Cushman, Fossil Bluff, U.T.G.D. 84219, x 25.

127 *Globulina gibba* (d'Orbigny), Fossil Bluff, U.T.G.D. 84220, x 25.

128,129 *Guttulina communis* (d'Orbigny), Fossil Bluff, U.T.G.D. 84221, x 25.

130 *G. frankei* Cushman and Ozawa, Fossil Bluff, U.T.G.D. 84222, x 30.

131 *G. lactea* (Walker and Jacob), Fossil Bluff, U.T.G.D. 84223, x 35.

132 *G. regina* (Brady, Parker and Jones) form A, Fossil Bluff, U.T.G.D. 84244, x 45.

133,134 *G. regina* (Brady, Parker and Jones) form B, Mussel Roe Bay, U.T.G.D. 84489, x 35.

135 *G. (?) schafferi* Cushman and Ozawa, King Island, U.T.G.D. 84490, x 40.

136 *G. yabei* Cushman and Ozawa, King Island, U.T.G.D. 84225, x 45.

137 *Pseudopolymorphina beaumarisensis* Parr and Collins, Fossil Bluff, U.T.G.D. 84226, x 35.

138 *P. subcylindrica* (Hantken), Fossil Bluff, U.T.G.D. 84227, x 35.

139 *P. tasmanica* Parr and Collins, Fossil Bluff, U.T.G.D. 84228, x 35.

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PLATE 4

140 *Pyrulina fusiformis* (Roemer), Fossil Bluff, U.T.G.D. 84230, x 50.

141 *P. gutta* d'Orbigny, Mussel Roe Bay, U.T.G.D. 84439, x 60.

142 *Sigmoidella elegantissima* (Parker and Jones), Fossil Bluff, U.T.G.D. 87231, x 35.

143 *Sigmomorphina chapmani* (Heron-Allen and Earland), Mussel Roe Bay, U.T.G.D. 84452, x 35.

144 *S. schwageri* (Karrer), Mussel Roe Bay, U.T.G.D. 84453, x 17.

145 *S. semitecta* (Reuss), Fossil Bluff, U.T.G.D. 84232, x 60.

146 *S. williamsoni* (Terquem), Marrawah, U.T.G.D. 84233, x 60.

147,148 *S. wynyardensis* Parr and Collins, Topotype, Fossil Bluff, U.T.G.D. 84234, x 35.

149 *Glandulina laevigata* d'Orbigny, Fossil Bluff, U.T.G.D. 84229, x 30.

150 *Fissurina annectens* (Burrows and Holland), Cape Grim, U.T.G.D. 84340, x 60.

151 *F. circulum* Seguenza, Fossil Bluff, U.T.G.D. 84235, x 70.

152 *F. cucullata* Silvestri, Fossil Bluff, U.T.G.D. 84236, x 60.

153 *F. marginata* (Montagu), Granville Harbour, U.T.G.D. 84342, x 60.

154 *F. quadrata*, (Williamson). Fossil Bluff, U.T.G.D. 84237, x 60.

155 *F. siciliensis* Loeblich and Tappan, Fossil Bluff, U.T.G.D. 84238, x 45.

156 *F. simplex* Seguenza, Cape Grim, U.T.G.D. 84239, x 60.

157 *Oolina apiculata* Reuss, Fossil Bluff, U.T.G.D. 84240, x 60.

158 *O. globosa* (Montagu), Fossil Bluff, U.T.G.D. 84241, x 60.

159 *O. inornata* d'Orbigny, Fossil Bluff, U.T.G.D. 84242, x 60.

160 *O. (?) multicosta* (Karrer), Mussel Roe Bay, U.T.G.D. 84405, x 60.

161 *Parafissurina* sp., Mussel Roe Bay, U.T.G.D. 84407, x 60.

Papers and Proceedings of the Royal Society of Tasmania, Volume 108

(ms. received 30.11.1973)

STATUS AND SUBDIVISION OF THE PARMEENER SUPER-GROUP

by

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(with one text figure)

ABSTRACT

Late Palaeozoic and Early Mesozoic rocks of the Parmeener Super-Group are subdivided on a strict lithostratigraphical basis, and not in the time terms 'Permian' and 'Triassic'.

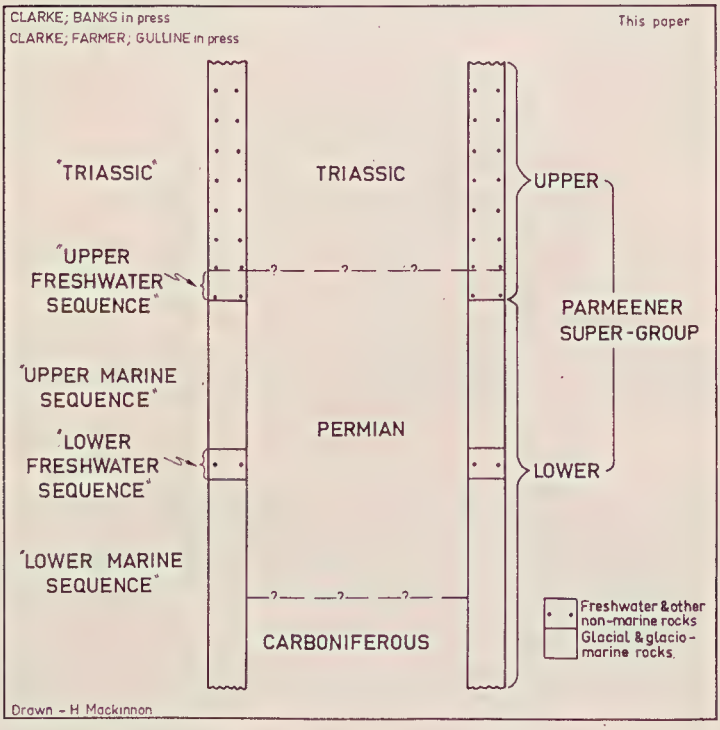
DISCUSSION

The name Parmeener Super-Group (Banks 1973) has recently been introduced to define a widespread Tasmanian sequence of Late Palaeozoic and Early Mesozoic rocks. These strata are almost always sub-horizontal, and they rest with pronounced landscape unconformity on a folded basement which includes rocks as young as Late Devonian or Early Carboniferous. The Parmeener Super-Group ranges in age from Late Carboniferous to Late Triassic, and this litho-stratigraphical unit has at many localities often been incorrectly described in the international time-rock unit terms. Whereas no further formal subdivision of the Parmeener Super-Group was proposed in the original definition, it was indicated that everywhere in Tasmania two broad lithological and environmental associations can be recognised. These are (1) a lower division which includes all glacial and glaciomarine beds; and (2) an upper and essentially freshwater division. Both divisions include subordinate coal measures.

The Permian/Triassic boundary, which has been used as a major division of the Parmeener Super-Group in the past, does not coincide with the boundary between the two broad lithological units, but occurs within the lower part of the essentially freshwater division. The Permian/Triassic boundary has proved unsatisfactory because of lack of fossils and it cannot be determined with sufficient accuracy for mapping purposes. The litho-stratigraphical boundary between the two major rock units, however, can be determined accurately during routine mapping, and it is proposed that this division be referred to in future.

The boundary between the Lower [division of the] Parmeener Super-Group and the Upper [division of the] Parmeener Super-Group is here defined as that between the 'Upper Marine Sequence' and the 'Upper Freshwater Sequence' of Clarke and Banks (in press) and Clarke, Farmer and Gulline (in press). It occurs at the base of the Cygnet Coal Measures (Late Permian) in southern Tasmania, and at the base of correlative horizons such as the Jackey Formation (Late Permian) at Poatina. In detail the Lower division includes such characteristic units as the Wynyard Tillite Formation, the Quamby Formation, the Golden Valley Group, the Masseys Creek Group, the Woody Island Siltstone Formation, the Darlington Limestone and the Bundella Formation (='Lower Marine Sequence'); the Liffey Group, the Mersey Coal Measures, the Faulkner Group and the Preolenna Coal Measures (='Lower Freshwater Sequence'); and the Cascades Group, the Malbina Formation, the Risdon Sandstone, the Ferntree Mudstone, the Poatina Group and the Bogan Gap Group (='Upper Marine Sequence').

Subdivision of the Parmeener Super-Group



The Sequences indicated in the diagram include the following characteristic units:

'Triassic' - Ross Sandstone Formation, Cluan Formation, Tiers Formation, Brady Formation, Springs Sandstone Formation and Knocklofty Formation.

'Upper Freshwater Sequence' - Cygnet Coal Measures, Jackey Formation, Clog Tom Sandstone Formation.

'Upper Marine Sequence' - Cascades Group, Malbina Formation, Ferntree Group, Poatina Group and Bogan Gap Group.

'Lower Freshwater Sequence' - Liffey Group, Faulkner Group, Mersey Coal Measures and Preolenna Coal Measures.

'Lower Marine Sequence' - Wynyard Tillite Formation, Quamby Formation, Golden Valley Group, Masseys Creek Group, Woody Island Siltstone Formation, Darlington Limestone Formation, Spreyton Beds, Kansas Creek Formation and Bundella Formation.

The Upper division includes the Cygnet Coal Measures, the Jackey Formation and the Clog Tom Sandstone Formation (='Upper Freshwater Sequence'); and the Ross Sandstone Formation, the Cluan Formation, the Tiers Formation, the Brady Formation, the Springs Sandstone Formation, the Knocklofty Formation and the Triassic coal measures (='Triassic').

In other words, the subdivision of Tasmanian Late Palaeozoic and Early Mesozoic rocks is based on local lithostratigraphical considerations. This procedure is considered to be an improvement on previous practice since neither the Permo-Carboniferous boundary nor the Permo-Triassic boundary can be located with any accuracy in Tasmania. All printed geological maps issued by the Geological Survey of Tasmania after July 1973, will incorporate the proposed lithostratigraphic subdivisions.

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(ms. received 12.2.1974)

A SIGHTING OF A LUTH (*DERMOCHELYS CORIACEA* (L.): CHELONIA) IN BASS STRAIT, TASMANIA

by G.F. van Tets, Division of Wildlife Research, CSIRO,

G.W. Johnstone and R. Williams, Antarctic Division,

Department of Science

At 09.00 h Eastern Daylight Saving Time on 8 December 1973 we observed a large turtle from the bow of the M.V. NELLA DAN. It was floating at the surface of the water with part of its carapace exposed, and swam slowly southwards out of the ship's path. According to the ship's log, NELLA DAN was at that time in Bass Strait in about 40°00's, 147°02'E, travelling on a course of 309° west of the Furneaux Group, Tasmania.

We estimated the turtle to be 2½ m long. It was grey and greenish in colour and had three prominent longitudinal dorsal ridges. We saw no indication of large scales on its back. From these characters it was concluded that the turtle was a Luth or Leathery Turtle, *Dermochelys coriacea* (Linnaeus, 1766). Luths have seven dorsal ridges (De Rooij 1915), but presumably only the median three were visible from above and the other four were obscured by the water.

The Luth occurs throughout the tropical and sub-tropical seas of the world (De Rooij 1915). Occasionally it is also reported from temperate localities, including seven records for Tasmania (Green 1971). Of these two from Fortescue Bay, 43°08's, 148°00'E are the furthest south in Tasmania (Scott and Mollison 1956a and b).

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LOWER DEVONIAN BRACHIOPODS FROM THE POINT HIBBS LIMESTONE OF WESTERN TASMANIA

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(with two text-figures and four plates)

ABSTRACT

Fourteen brachiopod species belonging to the following genera are described from the middle Lower Devonian (Siegenian) Point Hibbs Limestone, Tasmania: *Schizophoria*, *Isorthis*, *Cymostrophia*, *Megastrophia*, *Hipparionyx (?)*, *"Chonetes"*, *Machaeraria*, *Uncinulus*, *Hebeotoechia*, *Atrypa*, *Meristella*, *Athyris*, *Cyrtina*, and *Acrospirifer*. *Megastrophia hillae* sp. nov., *Hebeotoechia hibbensis* sp. nov., and *Acrospirifer banksi* sp. nov. are erected. This fauna displays close affinity to faunas recorded from the Coopers Creek Formation, the Lilydale Limestone, and the Tabberabbera Formation of Victoria, and the Baton River Beds of New Zealand.

INTRODUCTION

The Point Hibbs Limestone is a constituent formation of the Spero Bay Group: a succession which crops out along the shoreline north of Point Hibbs and along the northern shore of Spero Bay (Figure 1). The succession has been described by Banks (*in* Spry and Banks, 1962), and by Banks, Ahmad and Ford (1960). The sequence is illustrated in figure 2.

The fauna of the Limestone has been mentioned by several authors: Hill, 1942; Banks *in* Spry and Banks, 1962; Hill, 1967; Banks *in* Talent and Banks, 1967; Philip and Pedder, 1967; Jell and Hill, 1970; Strusz, 1972; and Picket, 1972.

This taxonomic study is based on two small collections of brachiopods, numbering about 350 specimens. The University of New England material was collected by A.E.H. Pedder and G.M. Philip in February, 1964, and is stratigraphically located mainly within the interval 45 to 90 metres above the base of the Point Hibbs Limestone (UNE macrofossil localities 455 and 456 respectively). These specimens have been assigned UNE numbers. The second collection, part of the University of Tasmania's fossil collection, includes brachiopods collected by M.R. Banks while mapping the Point Hibbs 1-mile Sheet. Specimens in this collection cannot be precisely located within the stratigraphic section. These specimens are assigned UT numbers. Attempts to locate a third suite of fossils, submitted to Robert Etheridge Jnr. in 1914 (mentioned in Hills, 1914, p.9), proved unseccessful. Neither the Australian Museum, nor the Geological Survey of New South Wales, knows of its whereabouts (*in litt.*, 9 September, 1969; 21 October, 1969 respectively).

FAUNA, AGE AND CORRELATION

The brachiopod fauna of the Point Hibbs Limestone includes *Schizophoria* sp. cf. *S. provularia* (Maurer), *Isorthis sp.* cf. *I. festiva* Philip, *Cymostrophia bellarugosa* Talent, *Megastrophia hillae* sp. nov., *Hipparionyx* (?) sp., *"Chonetes"* sp., *Machaeraria* sp. cf. *M. formosa* (Hall), *Uncinulus (?) globosus* Talent, *Hebeotoechia hibbensis* sp. nov., *Atrypa* sp. cf. *A. reticularis* (Linnaeus), *Meristella* sp., *Athyris* (?) sp., *Cyrtina heteroclita* (Defrance), and *Acrospirifer banksi* sp. nov.

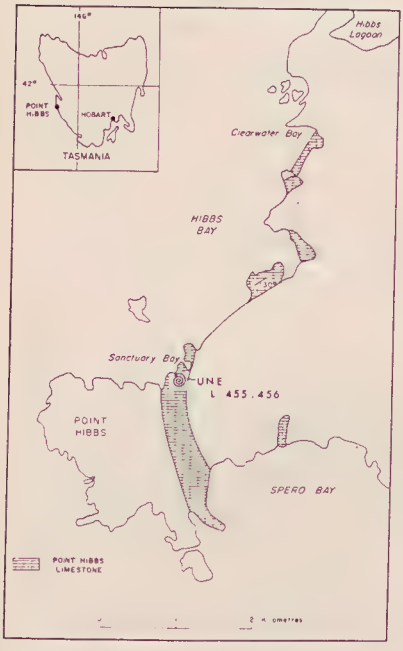

FIG. 1. - Map showing the distribution of the Point Hibbs Limestone.

Limestone (Philip and Jackson, 1970), and from the Garra Formation (Druce, 1970).

Intercontinental Lower Devonian biostratigraphic correlations have been under review (Savage, 1973b) since Carls (1969) demonstrated that Rhenish section was placed too low relative to the Bohemian section of the Lower Devonian. Therefore it has become necessary to reassign a Middle and Upper Siegenian age respectively to the Upper Yeringian and Tabberabberan Brachiopod Faunas. The Point Hibbs brachiopod fauna would be Middle to Upper Siegenian in age.

This fauna shows similarities with faunas described from the Coopers Creek Formation (Chapman, 1903; Philip, 1962), the Lilydale Limestone (Gill, 1945; 1950), and the Kilgower Member of the Tabberabbera Formation (Gill, 1945; 1949; Talent, 1963) all of Victoria, and the Baton River Beds (Shirley, 1938; Gill, 1945; Wright, 1967) of New Zealand. The fauna appears to be transitionary between the Upper Yeringian (Fauna II) and the Tabberabberan (Fauna III) Brachiopod Faunas described by Strusz (1972) from Eastern Australia (see Strusz, *op. cit.* for Intra-Australian correlations).

Corroborating evidence is afforded by the conodont fauna (Philip and Pedder, 1967) which contains *inter alia Spathognathodus sulcatus* (Philip) which has been recorded from the Coopers Creek Formation (Philip, 1965), the Lilydale Limestone (Philip and Pedder, 1967c), the Waratah

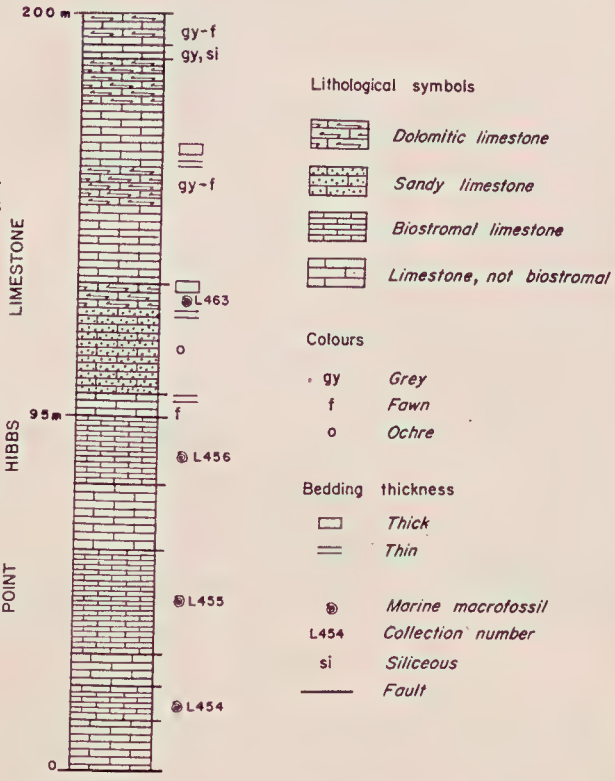

FIG. 2. - Section of the Point Hibbs Limestone, located on the northern side of Point Hibbs (measured by estimation, A.E.H. Pedder, February, 1964).

SYSTEMATIC PALAEONTOLOGY

Systematic designations above generic rank have been omitted. The classification given by Williams and Rowell (*in* Moore, 1965) may be consulted for taxonomic designations above the generic level. Definitions of morphological terms are contained in the brachiopod volumes of the Treatise on Invertebrate Paleontology (Moore, *op. cit.*).

Genus *Schizophoria* King, 1850

Type species. *Conchylilolithus (Anomites) resupinatus* Martin, 1809

Schizophoria sp. cf. *S. provularia* (Maurer, 1886)

Pl. 1, figs. 9-12

Material. 18 articulated and disarticulates shells.

University of New England: 10971 - 10985. University of Tasmania: 52132, 51931, 51389.

Description. Shells medium to large sized; unequally biconvex with brachial valve more convex than pedicle valve; cardinal extremities rounded; greatest width at midlength; hinge line straight, about half the width of the shell; dorsal valve without fold; anterior half of ventral valve with broad shallow sulcus; ventral interarea almost plane, apsacline; delthyrium high and narrow, open; dorsal interarea about half as long as ventral interarea, evenly curved, apsacline; notothyrium open, wide; external ornament of numerous fine rounded costellae, separated by narrow interspaces; costellae increase by bifurcation and intercalation; costellae crossed by few concentric growth lines.

Pedicle valve interior with long, strong, oblique dental plates, extending around the margin of the muscle area as a sharply defined ridge (Pl. 1, fig. 11); delthyrial cavity bounded by high dental plates; diductor scars only slightly divergent, separated by a narrow high ridge, presumably the site of attachment of the adductors; adjustor scars not observed; crural fossettes not seen.

Brachial valve interior with widely divergent brachiophores; fulcral plates define the sockets basally; sockets deep, notothyrial cavity occupied by a trilobate cardinal process with a thin triangular plate medially and two smaller rod-like lobes on either side; very low median ridge developed on valve floor, only extends a short distance; internal margin is crenulated by the costellae; musculature not observed.

Figured specimens. UNE 10973, 10971, 10976.

Discussion. *Schizophoria* sp. cf. *S. provulvaria* closely resembles *S. provulvaria* (Maurer) *sensu* Binnekamp (1965) from the Lower Siegenian Labanza Formation of Spain (see Renouf (1972 p. 100) for discussion). The only apparent difference is that the Tasmanian specimens have a slightly more pronounced muscle bounding ridge in the ventral valve, and the cardinal process appears to have fewer lateral lobes.

Gill (1942) described *S. provulvaria* from early Devonian strata in Victoria, and Shirley (1938) also described this species from the Baton River Beds of New Zealand. Until these specimens can be examined or comparative material collected, the author considers it best to assign the Point Hibbs material to cf. *S. provulvaria*.

S. sp. cf. *S. provulvaria* differs from other specific descriptions of *Schizophoria* in the following ways: it has a different arrangement of the pedicle valve musculature from the type species; *S. vulvaria* Schlotheim, figured by Comte (1938), possesses much finer costellation; the figure of *Schizophoria* sp., Talent (1963), from the Tabberabbera Formation, Victoria, is insufficient to allow specific comparison; *Schizophoria* sp.,

Philip (1963), from the Boola Beds, has different pedicle muscle impressions; *S. schnurri* Struve, figured by Anderson *et al.*, (1969) is flatter and has a different arrangement of the pedicle valve musculature; the Tasmanian specimens are unlike the three species and five subspecies of *Schizophoria* described by Struve (1965); *S. runegatensis* Renouf (1972) possesses a different muscle impression in the brachial valve.

The New Zealand material which Allan (1942) referred to *S. provulvaria* is now assigned to *Reeftonia* Allan (see Johnson & Talent, 1968).

Genus *Isorthis* Kozlowski, 1929

Type species. *Dalmanella (Isorthis) szajnockai* Kozlowski, 1929

Isorthis sp. cf. *I. festiva* Philip, 1962

Pl. 1, figs. 1-4, 8.

Material. 27 complete and incomplete shells.

UNE: 10987 - 11012. UT: 51985 - 51930.

Description. Shells medium sized, unequally biconvex; pedicle valve more convex than brachial; wider than long, maximum width near mid-length; cardinal angles obtuse, rounded to subangular; pedicle beak slightly incurved; interarea slightly curved, apsacline, about half to two-thirds the width of the shell; delthyrium open, higher than wide; poorly defined fold extends from the umbo; brachial interarea short, less than half the width of the shell, analcine; brachial beak small; a relatively deep sulcus extends from the beak; anterior commissure sulcate.

Surface multicostellate; costellae increasing by bifurcation, 15-19 costellae per five mm at ten mm from beak; surface may be marked by one or two pronounced concentric growth lines; shell substance punctate.

Pedicle valve interior with large, bluntly rounded teeth, supported by dental plates which continue anteriorly as low but distinct muscle bounding ridges; ventral muscle field elongate, extending about one-third the length of the valve, and consists of two expanding diductor scars separated by a narrow adductor ridge (Pl. 1, fig. 4); adjustor musculature not observed.

Brachial valve interior with moderately deep dental sockets, bounded by low fulcral plates, anteriorly bordered by prominent, but thin bladed, inner socket ridge; blade-like brachiophores diverge forward of the midline at about 50°; cardinal process with long shaft and usually a bilobed myophore, tending to close the notothyrium; muscle area subquadrate, extending more than half the length of the valve, with a wide median ridge; posterior adductors slightly larger than anterior adductors, line of separation not obvious.

Figured specimens. UNE 10987 - 9, 10992, 10994.

Discussion. The Point Hibbs specimens are assigned to *Isorthis* and not to *Reeftonia* (see Boucot *et al.*, 1967; and Johnson *et al.*, 1968, for discussion of *Reeftonia*) because they possess a strong pair of anteriorly divergent dental plates; the ventral diductor scars are divided by a narrow, anteriorly prominent adductor platform; the dental sockets are defined by low fulcral plates, and the dorsal adductor scars are quadripartite and so situated on the platform as to appear to have muscle bounding ridges both laterally and antero-laterally. *Isorthis festiva* is known from the Boola Beds (Philip, 1962) and the Mandagery Park Formation (Savage, 1971). The type specimens of *I. festiva* are of smaller size than the Point Hibbs specimens.

Genus *Cymostrophia* Caster, 1939

Type species. *Leptaena stephani* Barrande, 1848

Cymostrophia bellarugosa Talent, 1963

Pl. 1, figs. 5-7.

Material. 63 incomplete articulate shells.

UNE: 1103-45. UT: 5135?; 51357, -58, -63, -73, -79, -80; 51433, -72; 51580, -83; 51907, -21, -33, -40, -83, -86; 52110; 53302, -03.

Description. Shells medium to large sized, wider than long; angle of genticulation 80° - 90° at anterior margin, decreasing towards the rectangular cardinal extremities; maximum width along hinge line; hinge line denticulate for greater than half its width; ventral inter-area low, flat, apsacline to orthocline; pseudodeltidium slightly convex; pedicle valve weakly convex, anterior and lateral margins bent dorsally, producing a long trail; visceral disc separated from trail by an inconspicuous edge; pedicle and brachial valves closely fitting; delicate papillae on both valves.

Prominent transverse rugae on disc of both valves, and interrupted by costellae; ornamentation of costellae and fine capillae; between eight and twelve costellae per 10 mm measured parallel to, and 10 mm from the hinge line; average of eight capillae between costellae, but increasing to fifteen or seventeen when central capillae become costellae.

Internals not observed.

Figured Specimens. UNE 11015-7.

Discussion. The type specimens of *Cymostrophia bellarugosa* Talent are from the Kilgower Member of the Tabberabbera Formation. The following forms which may be closely related to *C. bellarugosa* have been described: *Cymostrophia* sp. indet., and *Megastrophia* (?) sp. by Philip (1962) from the Coopers Creek Formation; *C. stephani* by Shirley (1938) and Allan (1942) from the Baton River Beds. As nothing is known of the interiors or degree of variation of these, no meaningful comparison can be made.

Genus *Megastrophia* Caster, 1939

Type species. *Strophomena (Strophodonta) concava* Hall, 1857

Megastrophia hillae sp. nov.

Pl. 2, figs. 7-9.

Name. Patronym in honour of Dorothy Hill who was the first palaeontologist to suggest a Devonian age for the Point Hibbs Limestone.

Material. Four complete and ten incomplete shells.

UNE: 11046, 11048-50. UT: 51911, -25, -46, -68, -76, -89; 51266, 51376; 94095.

Diagnosis. Small to medium sized, thin shelled *Megastrophia* with strongly developed ornament.

Description. Shells of small to medium size, concave-convex, with the pedicle valve gently arched; cardinal extremities subrounded; hinge line straight, denticulated three-

quarters the width of the valve; maximum width occurs posterior of midlength; ventral interarea long, flat, apsacline; delthyrium small, covered by pseudodeltidium; dorsal interarea long but narrow; ornamentation of costellae that increase by bifurcation and intercalation; shell substance pseudopunctate.

Pedicle valve interior with well developed myophragm, anterior of the umbo; nature of the dental plates or musculature unknown.

Brachial valve interior with low cardinal process, with posteriorally disjunct lobes, also divided into two circular muscle fields inserted on a gently elevated platform, divided by a low, narrow median ridge.

Figured specimens. Holotype UT 94095; paratypes UNE 11049, 11050.

Discussion. The pedicle valve interior impression of *Megastrophia hillae* sp. nov. illustrated on Pl. 2, fig. 9, shows close resemblance to the interior of *M. iddingsi* (Merrian), and the exterior ornament resembles *M. transitans* Johnson (see Johnson, 1970, pp. 120-123, Pl. 26, fig. 9). There are no known species of *Megastrophia* from eastern Australia that show any similarity to *M. hillae* sp. nov.

Genus *Hipparionyx* Vanuxem, 1842

Type species. *Hipparionyx proximus* Vanuxem, 1842

Hipparionyx (?) sp.

Pl. 2, figs. 10, 14

Material. Five incomplete and poorly preserved brachial valves.

UNE: 11068 - 70. UT: 51945, 51913.

Description. Exceptionally large shells, with rounded cardinal extremities; ornamentation of costellae that increase by bifurcation; brachial valve interior with high, divergent cardinal process lobes (Pl. 2, fig. 10) and median septum; no other features observed.

Figured specimens. UNE 11068-9.

Discussion. Talent (1963, p. 66) has discussed the problem of the assignment of Australian orthotetaceans to the genus *Hipparionyx*. The Point Hibbs specimens are so few and so poorly preserved, that they can only be questionably referred on the basis of a few morphological features to the previously described Australian species (Compare Pl. 2, fig. 14, with Talent, 1963, Pl. 31, fig. A2).

Species of *Hipparionyx* have been recorded by Shirley (1938) from the Baton River Beds, by Gill (1942, 1949) from sediments at Sandy Creek, and by Talent (1963) from the Tabberabbera Formation.

Genus *Chonetes* Fisher de Waldheim, 1830

Type species. *Terebratulites sarcinulatus* von Schlotheim, 1820

"Chonetes" sp.

Pl. 2, figs. 5-6

Material. Three incomplete pedicle valves.

UNE: 11071 - 3.

Description. Pedicle valve is medium to large sized, moderately convex; hinge line straight, slightly less than maximum width; ornament consisting of low rounded radiating costae, originating in the umbonal and hinge line region; costae increase by bifurcation; spines or concentric growth lines not observed.

Figured specimens. UNE 11071-2.

Discussion. The Point Hibbs material is referred to as *"Chonetes"* because many of the Victorian and southern New South Wales chonetid species are now referred either to *Parachonetes* or to *Protochonetes*. A more definite assignment would require material illustrating the internal structures of both valves.

"Chonetes" sp. may be closely related to *Chonetes robusta* Chapman (1903) which has been recorded from the Lilydale area (Gill, 1945), and from the Baton River Beds (Gill, 1952). Gill's illustrations are too poor for a detailed comparison.

"Chonetes" sp. has similar arrangement of costae, but is of smaller size than *Chonetes baragwanathi* Gill, described by Talent (1963) from the Tabberabbera Formation.

Genus *Machaeraria* Cooper, 1955

Type species. *Rhynchonella formosa* Hall, 1857

Machaeraria sp. cf. *M. formosa* (Hall)

Pl. 3, figs. 5-6, 9-12.

Material. 51 complete shells.

UNE: 11077 - 11122. UT: 51337, -73, -74, -77, -95; 51407, -12, -28; 51926, -42, -55, -64; 52100, -04, -08, -67.

Description. Shells small to medium sized, inequivalved, subpentagonal biconvex; wider than long; greatest width and height forward of midlength; cardinal extremities rounded; hinge line curved and small; ventral valve moderately convex; suberect beak; small submesothyrid foramen; delthyrium medium sized, restricted by narrow disjunct deltidial plates; sulcus wide and deep bearing three plications, increasing by intercalation; dorsal valve strongly convex; broad umbo; small uncurved beak; fold wide and low, bearing four plications, increasing by bifurcation; anterior commissure strongly uniplicate; sinus strongly trapezoidal; surface ornament of 12-24 strong angular plications; number of plications on lateral slopes constant for each specimen; fine growth lines visible on well preserved specimens.

Pedicle valve interior with short, narrow dental plates supporting slender teeth, with small fosettes which articulate with the outer edge of the inner socket ridges; musculature not observed.

Brachial valve interior with divided hinge plate; outer plates broad and triangular, serve as crural bases; crura long and curved, free end bluntly pointed, conjunct posteriorly, forming a narrow elongate norothyrial cavity, occupied by a long thin cardinal process; musculature not impressed.

Figured specimens. UNE 11077, 11088-89.

Discussion. The Point Hibbs specimens resemble *M. formosa* (Hall) in external morphology, but definite assignment is deferred until comparative material can be obtained. The Point Hibbs specimens consistently display four plications on the fold and three in the sulcus. This, together with the angular nature of the plications, readily distinguishes them from *M. catombalensis* Strusz (1970), *M.* (?) sp. Talent (1963), and *M.* cf. *formosa* described by Savage (1971).

Genus *Uncinulus* Bayle, 1878

Type species. *Hemithyris subwilsoni* d'Orbigny, 1850

Uncinulus (?) globosus Talent, 1956

Pl. 2, figs. 1-4.

Material. 23 complete shells.

UNE: 11148 - 69. UT: 51433; 51984.

Description. Shells small, unequally biconvex, subpentagonal to rounded in outline; lateral margins rounded; postero-lateral margin slightly concave and meeting in an acutely angular beak; beak slightly incurved to suberect; foramen minute; fold and sulcus begin anterior of mid-length; fold bears a medium depression; sulcus with an enlarged costae which appears as a median fold; anterior commissure strongly uniplicate; external ornament of 13 to 27 costae, commonly bifurcating near the anterior margin; sulcus bearing three plications; fold bearing four plications.

Pedicle valve interior with posteriorly located dental plates; teeth, musculature, median ridge not seen.

Brachial valve interior with very shallow septalium, supported posteriorly by a high, narrow median septum; median septum extends up to one third the length of the valve; hinge plate broad, thin and anteriorly divided; dental sockets narrow; musculature not distinguishable; cardinal process not observed.

Figured specimens. UNE 11154-55.

Discussion. The subtlety of the differences between the related genera of the Rhynchonellacea, added to the fact that the internal structure of *Uncinulus (?) globosus* Talent is not known, makes a definite generic assignment of this species questionable.

It was impossible to determine the true nature of the internal structure of the Tasmanian specimens because their very small size renders serial sectioning techniques useless and they are assigned to *U. (?) globosus* solely on the basis of their similar external morphology. *U. (?) globosus* is known from the Coopers Creek Formation (Talent, 1956)

Genus *Hebeotoechia* Havlíček, 1959

Type species. *Terebratula hebe* Barrande, 1848

Hebeotoechia hibbensis sp. nov.

Pl. 3, figs. 1-4, 7-8.

Name derivation. Point Hibbs, a headland on the western coast of Tasmania, where the species is known to occur.

Material. 50 complete and incomplete articulated shells, and six incomplete disarticulated shells.

UNE: 11123 - 11145. UT: 51360, -61, -66, -67; 51371, -75, -78, -81, -83, -84, -86, -90; 51402, -3, -5, -16, -21, -26, -27, -65, -66; 51582; 51959, -60, -74, -80, -91; 52107, -28, -33, -56; 53300; ?6908; 5336?

Diagnosis. Medium to exceptionally large sized *Hebeotoechia*, with 28 to 52 costae, increasing by bifurcation; fold and sulcus almost imperceptible; sulcus with five to seven costae; ventral muscle field circular, shallowly impressed; dental plates almost obsolete; teeth large; septalium supported by a median septum and filled out in its posterior part with callus projecting above the hinge plate as a bilobed process.

Description. Shells medium to large sized, biconvex, rounded to subpentagonal in outline; suberect pedicle beak; minute foramen; fold and sulcus almost imperceptible, developed slightly posterior of mid-length; anterior commissure strongly uniplicate; external ornament of 28 to 52 low, slightly rounded bifurcating costae, separated by narrow furrows; sulcus bears five to seven costae; longitudinally grooved costae near the commissure.

Pedicle valve interior with almost obsolete concave dental plates, supporting strong, blunt teeth; small circular muscle field shallowly impressed; pedicle cavity small.

Brachial valve interior with deep septalium, supported posteriorly by a high, narrow median septum; septalium filled out in its posterior part with callus forming the cardinal process; cardinal process bilobed and bears a bordering ridge; always a groove between the two lobes of callus; hinge plate thin and bearing short dental sockets bounded by the cardinal margin and the inner socket ridges; median septum extending about one-third the length of the valve; musculature not distinguishable.

Figured specimens. Holotype UT 51416; paratypes UNE 11123; UT 51421.

Discussion. The Point Hibbs specimens are assigned to *Hebeotoechia* Havlíček and not to *Plethorhyncha* Hall and Clarke on the basis of the internal structure of the brachial valve. Havlíček (1961, p. 119) remarks that the septalium of *Hebeotoechia* bears a bilobed cardinal process that always has a groove between the two lobes, whereas *Plethorhyncha* has a completely callus filled septalium.

Hebeotoechia hibbensis sp. nov. differs in external form from the four species, *H. hebe* (Barrande), *H. ornatrix* Havlíček, *H. compta* (Barrande), and *H. nitidula* (Barrande) described by Havlíček in 1961. It also differs in external shape from *H. cantabrica* Binnekamp (1965), and from *H.* cf. *H. hebe* described by Lenz (1970).

Philip (1962, p. 216) referred to the presence of large rhynchonellids in the Lower Devonian of Victoria and suggested that the Lilydale form identified as *Eatonia (Eatonia)* affin. *bithynica* Gill (1952) (= ? *Uncinulus stricklandi* Sowerby, Chapman 1903, p. 78) could represent a species of *Plethorhyncha*. *E. bithynida* has been recorded by Shirley (1938) from the Baton River Beds. Talent (1963, p. 76) also commented on the presence of large cuboidal rhynchonellids in the Lower Devonian of Victoria. He referred specimens from Lilydale and from Tabberabbera to *Sphaerirhynchia* Cooper and Muir Wood, but qualified this assignment by suggesting that the forms could be assignable to *Hebeotoechia*. Unfortunately, the internal structures of the Victorian and New Zealand rhynchonellids are poorly known and so a detailed comparison with the Tasmanian material is not meaningful.

Genus *Atrypa* Dalman, 1828

Type species. *Anomia reticularis* Linnaeus, 1758

Atrypa sp. cf. *A. reticularis* (Linnaeus)

Pl. 4, figs. 5, 10, 15.

Material. 11 complete shells.

UNE: 11179 - 87. UT: 51928; 53118.

Description. Shells medium to large sized; unequally biconvex, brachial valve more convex than pedicle valve; cardinal extremities subrounded; hinge line straight; maximum width near or posterior of midlength; dorsal fold and ventral sulcus present towards anterior margin; commissure gently uniplicate; pedicle beak pointed, suberect to slightly incurved; brachial beak strongly incurved, not exposed externally; interarea or delthyrium not observable.

Ornament of well developed, rounded radial costae, numbering about ten per 10 mm at 20 mm from the beak; costae separated by narrow U-shaped interspaces; costae commonly increase by bifurcation on the pedicle valve, and by intercalation on the brachial valve; costae increase in size anteriorly; concentric growth lines only moderately defined posteriorly.

Pedicle valve interior with large blunt teeth, joined to the lateral margin of the shell and supported by dental plates which are sometimes obscured by secondary shell deposition; bounding the teeth posterolaterally are two well developed secondary dental sockets; the dorsal end of the tooth is notched by a shallow groove; musculature deeply impressed.

Brachial valve interior with what appears to be a small cardinal process; deep dental sockets are defined between the postero-lateral edge of the valve and the prominent, strongly curved crural plates; crural lobes recurve ventrally and then laterally to cover the inner edge of the posterior part of the sockets; the sprialium consisting of about 13 turns; apices of the spiralia are close to the inner surface of the valve; median septum absent; musculature not observed.

Figured specimens. UNE 11179, 11182.

Discussion. The species name cf. *A reticularis* is generally used for forms close to the type species of *Atrypa*, because the original description, and Alexander's (1949) revision of the type species allow a wide range of forms to be placed in this species. Atrypids of this type constitute an exceedingly common and widespread group, many forms of which have names that have been erected with little or no regard to comparable forms.

Numerous Australian atrypids have been referred to as *Atrypa reticularis*. Gill (1950) described *Atrypa reticularis* from Lilydale; Chapman (1903) described *A. reticularis* var *decurrens* from the Coopers Creek Formation and Boola Beds; Philip (1962) described *A.*, sp. cf. *A. reticularis* from the Boola Beds; Talent (1963) described *A.* cf. *reticularis* from the Tabberabbera Formation; Mitchell and Dun (1920) recorded *A. reticularis* from several localities in southern New South Wales; and Savage (1970) recorded a new subspecies *A. reticularis inversa* from the Mandagery Park Formation.

Until a comprehensive study is made of all Australian atrypids and a comparison made with overseas species, it would be unreasonable to positively identify the Point Hibbs material as the species *A. reticularis* as there is an enormous range of variation in shape and external ornament within that species (see *Atrypa reticularis* figured by Bowen (1967, Pl. 5, figs. 28-40), *A. "reticularis"* figured by Boucot and Johnson (1968, Pl. 3, figs. 30-49) or *A. "reticularis"* figured by Anderson *et. al.*, (1969, Pl. 7, figs. 6-19).

Genus *Meristella* Hall, 1860

Type species. *Atrypa laivis* Vanuxem, 1842

Meristella sp.

Pl. 2, figs. 11-13

Material. One complete and eight incomplete shells.

UNE: 11170 - 2; 11174; 11177 - 8.

Description. Shells medium sized, sub-equally biconvex, subcircular in outline, elliptical in profile; lateral slopes from the umbo to mid-length almost straight; length greater than width; maximum width occurring slightly posterior of midlength; hinge line short with rounded cardinal extremities; pedicle foramen small, suberect beak; sulcus and fold absent; ornament of cencentric growth lines crossed by closely crowded radial lines.

Pedicle valve interior with long, strongly divergent dental plates; teeth not observed; median septum absent; musculature indistinct.

Brachial valve interior with long, high median septum extending up to midlength; median septum united to the well defined dental sockets to form a shallow cruralium; spiralium and jugum not seen; musculature indistinct.

Figured specimen. UNE 11170.

Discussion The Point Hibbs specimens are so few and so poorly preserved that a precise specific assignment is not possible. *Meristella* has been recorded from the Bell Shale (Gill, 1950), Lilydale (Gill, 1950b), Boola Beds (Philip, 1962), and from the Mandagery Park Formation (Savage, 1971).

Genus *Athyris* McCoy, 1844

Type species. *Terebratula concentrica* von Buch, 1834

Athyris (?) sp.

Material. Three poorly preserved, incomplete shells.

UNE: 11173, -5, -6.

Description. Shells small sized, subequally biconvex, subcircular in outline; maximum width occurs close to midlength; cardinal angles obtuse and well rounded; dorsal fold and ventral sulcus slightly developed; pedicle beak slightly incurved; no other features observable.

Pedicle valve interior with short dental plates, gently concave medially; teeth not observed; median septum absent; musculature indistinct.

Brachial valve interior with well defined dental sockets; hinge plate short, perforated posteriorly, conjunct anteriorly; crura short, widely divergent; median septum absent; no other features observable.

Discussion. The degree of recrystallisation and scarcity of specimens hinders precise definition of the Point Hibbs material. The general shape, divergent dental plates, perforate hinge plate, and absence of a median septum are suggestive of *Athyris*, to which the material is tentatively assigned.

Chatterton (1969) has shown that the internal structure of *Buchanathyris waratahensis* Talent (1956) agrees with that of *Athyris*. It would appear that the validity of the genus *Buchanathyris* Talent, 1956, is questionable and that forms from the Tabberabbera Formation, described by Talent (1963) could be just as well assigned to *Athyris*. The Point Hibbs specimens show resemblance to *B. westoni* (?), described by Talent (1963) from the Kilgower Member, but the preservation of the material in either collection, is insufficient to allow a more precise comparison.

The Point Hibbs specimens are relatively flatter than the figured types of *B. westoni* Talent (1956) from the Buchan Caves Limestone.

Genus *Cyrtina* Davidson, 1858

Type species. *Calceola heteroclita* Defrance, 1828

Cyrtina heteroclita (Defrance)

(Pl. 4, figs. 1, 6, 11

1962 *Cyrtina* cf. *hamiltonensis*, Banks *in* Spry and Banks, p. 185.

1967 *Cyrtina* cf. *hamiltonensis*, Banks *in* Talent and Banks, p. 159.

Material. 27 complete, or almost complete shells.

UNE: 11188 - 11208. UT: 51924, -31, -47, -70, -77, -90, -93.

Description. Shells medium sized, strongly unequally biconvex; the brachial valve weakly convex, uniform convexity; pedicle valve deep and hemipyramidal, in some deformed; pedicle beak pointed, erect to slightly curved at the posterior tip; ventral interarea high, triangular, planar to moderately concave, apsacline, divided by a long narrow delthyrium; subhypothyridid foramen present at apex of delthyrium; brachial interarea narrow and inconspicuous; cardinal angles acute (60° - 85°); maximum width at or slightly anterior of the hinge line; fold and sulcus prominent, extending from the posterior margin to the parasulcate anterior commissure; fold commonly flattened along its crest; lateral margins convex, bearing three to four rather strong rounded plications on either side of fold and sulcus; micro-ornament consists of irregularly spaced, concentric growth lemellae; shell substance finely punctate.

Pedicle valve interior with convergent dental plates, paralleling the inner edge of the delthyrium and uniting just above the floor of the valve to form a prominent spondylium, supported by a high median septum which intrudes the spondylial cavity as a trichorhinum; teeth of moderate size; muscle scars not observable.

Brachial interior with deep triangular dental sockets, supported by anteriorly divergent crural bases; crural plates absent; spiralia large, occupying most of the shell interior, each consisting of five to six volutions; median septum, cardinal process or musculature not observable.

Figured specimens. UNE 11189; UT 51393.

Discussion. Specimens from Point Hibbs are similar to *C.h. gregale* Talent (1963) in that they have similar numbers of plicae, and a deep pedicle valve that at times is twisted. Unfortunately, the originals of *C. h. gregale* consists of moulds which are distorted thus making detailed comparison with the Point Hibbs material difficult. The illustrations of specimens from the Baton River Beds of New Zealand which Shirley (1938) referred to as *C. heteroclita* are inadequate to allow any comparison with the Point Hibbs material.

An examination of the type specimens of *C. wellingtonensis* (Dun, 1904) and silicified topotypic material collected by Dr. D.L. Strusz from the Garra Formation, reveals that the Point Hibbs species can be distinguished by its smaller cardinal angle, flatter fold, less convex brachial valve, relatively larger size, and its "rugged" appearance.

Genus *Acrospirifer* Helmbrecht and Wedekind, 1923

Type species. *Spirifer primaevus* Steininger, 1853, by designation of Wedeking, 1926, p. 202.

Acrospirifer banksi sp. nov.

Pl. 4, fig. 2-4, 7-9, 12-14.

1962 *Acrospirifer*, Banks *in* Spry and Banks, p. 185.

1962 *Acrospirifer*, Banks *in* Talent and Banks, p. 159.

Name derivation. Patronym in honour of Maxwell Banks of the University of Tasmanian who collected many of the brachiopod specimens.

Material. 85 complete and incomplete shells.

UNE: 11209-11214, 11216-62. UT: 51306, -82, -94, -97, -99; 51400, -01, -17, -19; 51579, 51910, -2, -17, -19, -29, -32; 51942, -44, -49, -50, -51, -62, -73, -75, -87, -92, -93; 52124; 57906; 94096.

Diagnosis. Small to medium sized *Acrospirifer* with few (three to eight, commonly three to six) plications; plications broad and low showing a marked size increase anteriorly and marked size decrease postero-laterally; hinge line straight; cardinal extremities acute to obtuse (80^{o} - 105^{o}), evenly rounded; pedicle interarea long, curved, and bearing longitudinal and transverse striations; triangular delthyrium open and bordered by small deltidial plates; micro-ornament of distinct low concentric growth lamellae crossing the plications, and each bearing closely spaced tear-shaped granules.

Descriptions. Shell of small to medium size, unequally biconvex, wider than long; pedicle valve slightly more convex than brachial valve; hinge line long and straight, the place of maximum width; cardinal extremities acute to obtuse (80^{o} - 105^{o}) and subrounded; pedicle beak hooked at the posterior end; pedicle interarea long, low, triangular, slightly curved and apsacline, longitudinally and transversely striated; delthyrium triangular, open, and bordered by small deltidial plates (Pl. 4, fig. 9); brachial beak slightly incurved over the hinge area.

External ornament of three to eight well defined broad, rounded plications on each lateral slope; progressively narrower than adjoining plications; well developed noncostate brachial fold and pedicle sulcus, fold wider than high; micro-ornament of distinct low concentric lemellae crossing the plications of each lamellae bearing a row of closely spaced tear shaped granules.

Pedicle valve interior with long, well defined dental plates, widely divergent basally, commonly almost obsolescent by thick developments of secondary shell material in the umbonal cavity; teeth strong and suboval; inner surface strongly crenulated by the impression of the plications; musculature indistinct.

Brachial valve interior with short, deep dental sockets, divergent anterolaterally; socket plates thickened by the attachment of plate-like crural bases, but crural plates absent; inner surface moderately crenulated by the impression of the plications; musculature indistinct; cardinal process not observed; nature of spiralium unknown.

Figured specimens. Holotype UT94096 ; Paratypes UNE 11210 - 13 and UT 51400.

Discussion. *A. banksi* appears to be closely related to the large pauciplicate forms with deep U-shaped interspaces that are common in the Siegenian strata of the European sequence (Drot, 1964; Vandercammen, 1963), and to forms described as *A.* aff. *murchisoni* (Castelneau) from the *Trematospira* Zone of Nevada (Johnson, 1970, Pl. 56, figs. 5-13).

A. banksi differs from *A. lilydalensis* (Chapman, 1913) in that the latter possesses a feebly plicated ventral sulcus; a longitudinally striated dorsal fold; and eight to ten plications on each side of the fold and sulcus. Shirley's (1938) illustrations of *Acrospirifer arduennensis* from the Baton River Beds are too poor to allow comparison with the Point Hibbs specimens.

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PLATE 1

All specimens were whitened with ammonium chloride.
All figures x2 except 5 - 7 x 1½ and 4, 8 x 4.

Figs 1 - 4, 8. *Isorthis* sp. cf. *I. festiva* Philip, 1962. 1-3, Posterior, anterior, and dorsal views, UNE F10987 - 9 respectively. 4, Cast of pedicle valve interior, UNE F10992. 8, Brachial valve interior, UNE F10994.

Figs 5 - 6. *Cymostrophia bellarugosa* Talent, 1963. Ventral, dorsal, and ventral views, UNE F11015, 11017 and 11016.

Figs 9 - 12. *Schizophoria* sp. cf. *S. provularia* (Maurer, 1886). 9 - 10, Cast of ventral valve interior, and anterior, UNE F10971. 11, Interior of pedicle valve, UNE 10976. 12, Ventral, view, UNE F10973.

PLATE 2

All specimens were whitened with ammonium chloride.
All figures x3 except 10 and 14 x 2.

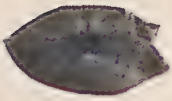
Figs 1 - 4. *Uncinulus (?) globosus* Talent, 1956. Ventral, dorsal, ventral and anterior views of UNE F 11154, 11154, 11155 and 11155 respectively.

Figs 5 - 6. *"Chonetes"* sp. Ventral views UNE F11072, 11071.

Figs 7 - 9. *Megastrophia hillae* sp. nov. Dorsal, ventral, and mold of pedicle valve interior of holotype UT 94095 and paratypes UNE 11049 and 11050.

Figs 10, 14. *Hipparionyx* (?) sp. Brachial valve interior, and shell ornament UNE 11068 and 11069.

Figs 11 - 13. *Meristella* sp. Posterior, lateral, ventral views of UNE 11170.



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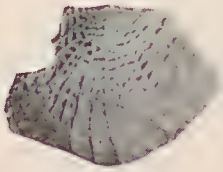

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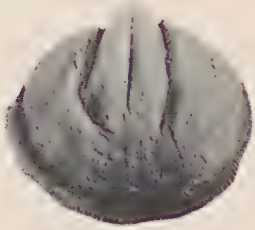

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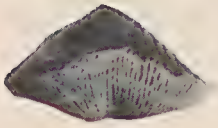

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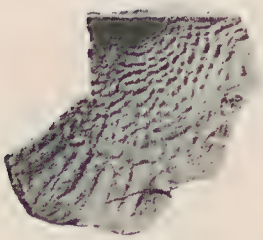

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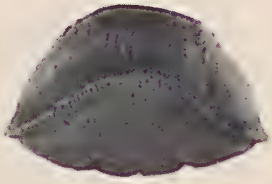

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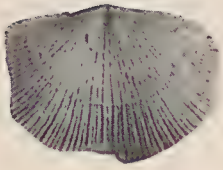

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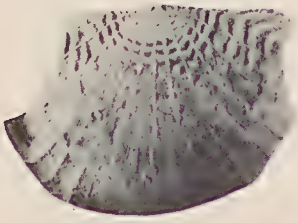

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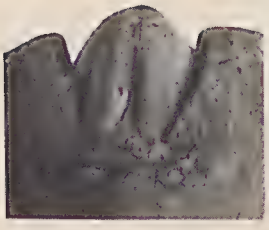

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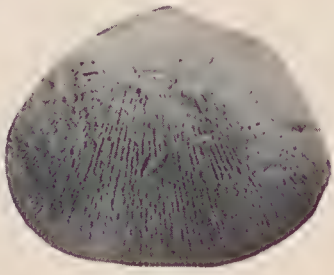

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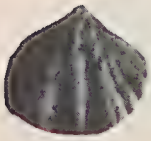
PLATE 1



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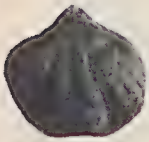

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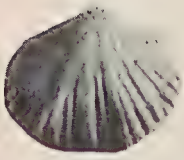

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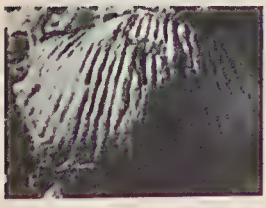

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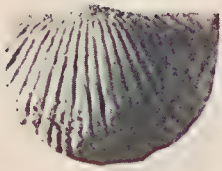

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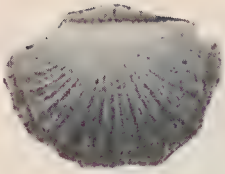

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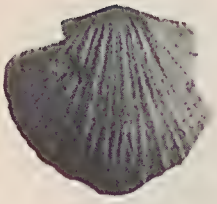

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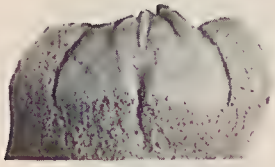

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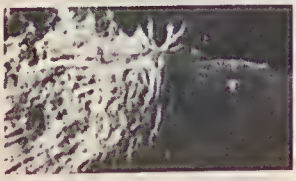

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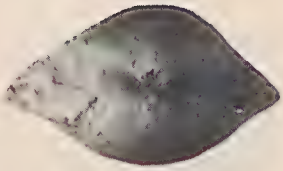

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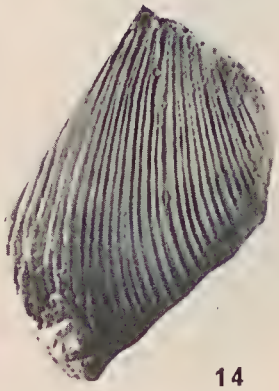

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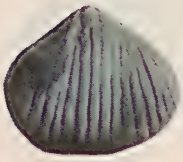
PLATE 2



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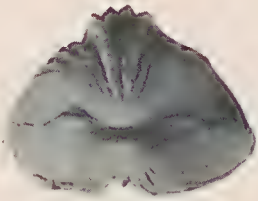

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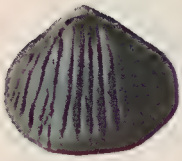

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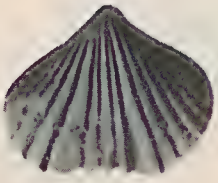

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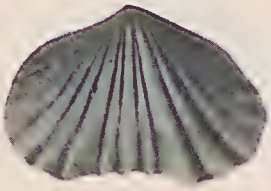

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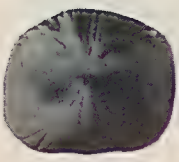

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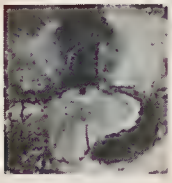

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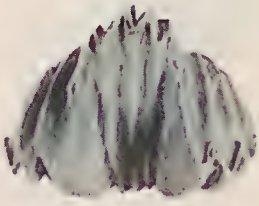

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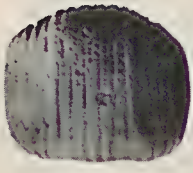

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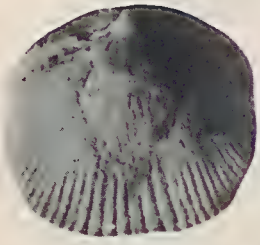

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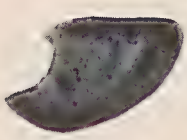
PLATE 3



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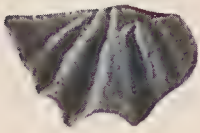

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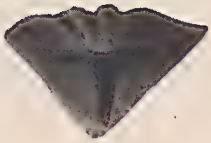

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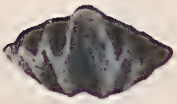

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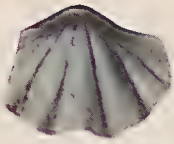

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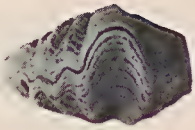

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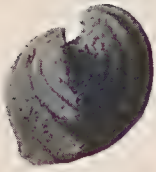

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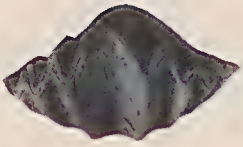

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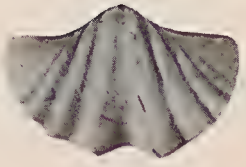

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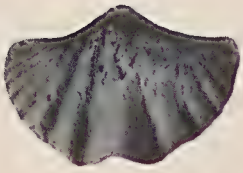

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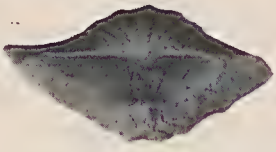

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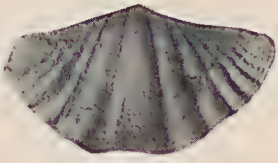

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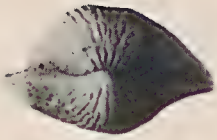

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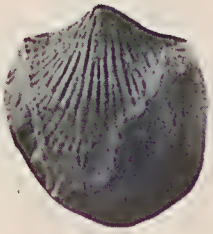

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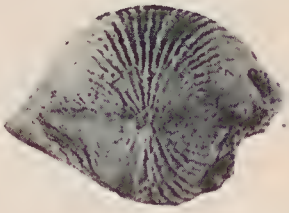

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PLATE 4

PLATE 3

All specimens except 7 were whitened with ammonium chloride. All figures x 1½ except 5, 6, 9 - 12 x 2.

Figs 1 - 4, 7 - 8. *Hebeotoechia hibbensis* sp. nov. 1 - 4, Ventral, dorsal, posterior, and anterior views, holotype UT 51416. 6, Transverse section of cardinal process, paratype UNE F 11123. 8, Cast of pedicle valve interior, paratype UT 51421.

Figs 5 - 6, 9 - 12. *Machaeraria* sp. cf. *M. formosa* (Hall, 1857) 5 - 6, Lateral and ventral views, UNE F 11088. 9 - 12, Posterior, ventral, anterior, and ventral views of UNE 11077, 11089, 11077 and 11077 respectively.

PLATE 4

All specimens were whitened with ammonium chloride.

All figures x 2 except 1, 6 and 11 x 3.

Figs 1, 6, 11. *Cyrtina heteroclita* (Defrance, 1828) Lateral, dorsal, and posterior views of UT 51393, UNE F11189 and UT 51393 respectively.

Figs 2 - 4, 7 - 9, 12 - 14. *Acrospirifer banksi* sp. nov. Anterior, lateral, dorsal, dorsal, anterior, posterior, anterior, ventral, and ventral views of paratypes UNE F 11210; 11212, UT 51400, UT 94096 (holotype) UNE F 11213, UT 51400 and UNE F 11215.

Figs 5, 10, 15. *Atrypa* sp. cf. *A. reticularis* (Linnaeus, 1758). Anterior, ventral, and anterior views of UNE F11179, 11179, and 11182.

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THE ERUPTION AND GROWTH OF TEETH IN THE TASMANIAN DEVIL, *SARCOPHILUS HARRISII* (MARSUPIALIA: DASYURIDAE).

by Eric R. Guiler and R.W.L. Heddle

Departments of Zoology and Anatomy,
University of Tasmania, Hobart.

(with one text figure and one plate)

ABSTRACT

The sequence of tooth eruption in *Sarcophilus harrisii* was found to follow an anterior-posterior sequence with two exceptions. The first incisors of the upper jaw did not erupt until the cessation of suckling at about 200 days and the canines did not appear until after the commencement of molar eruption.

Although considerable variation exists in the time and sequence of eruption of the teeth, the age of the young can be determined using shank length and weight in combination with the status of the teeth.

INTRODUCTION

The homologies of the teeth of the Marsupialia were first described by Flower (1867) who showed that only one tooth, which corresponded to the last premolar of the Eutheria, was preceded by a deciduous tooth. Further, he found that this feature was homologous throughout the Marsupialia.

Thomas (1887) in a detailed study of the teeth of the Dasyuridae noted that the dental formula of *Sarcophilus* was $\frac{4}{3}: \frac{1}{1}: \frac{2}{2}: \frac{4}{4}$:s and showed that the two premolar teeth which disappeared from the complete succession were P2 and P4. He reported that the first incisor, which in the adult is the largest incisor tooth, is slow to develop relative to the other incisors and postulated that they represent the stage at which the Metatheria and Eutheria diverged and the teeth were "preparing themselves" for the assumption of milk dentition. This view was not accepted by Wilson & Hill (1897), Tims (1902) or Bensley (1903).

Little further attention has been paid to the teeth of the Dasyuridae but the dentition of the Phalangeroidea, particularly the Macropodidae, has been the subject of much recent detailed examination. It has been shown that the molar eruption sequence of the larger species of kangaroos takes place over a period of years and, further, the molars progress anteriorly with age (Sharman et al, 1964). The stages of molar eruption and progression have been used as an aid to determining the age of individual animals by Shield (1958), Sadleir (1961) and Ealey (1962).

The present study was undertaken to determine the succession of events in tooth eruption in relation to age in the late pouch young and early juveniles of the Tasmanian devil, a carnivorous marsupial.

MATERIALS AND METHODS

Four pouch young, two of each sex and all litter mates, were selected for the study. The age of the animals was determined from criteria established earlier (Guiler 1970) and is given in days after birth. At the commencement of the study the young had to be forcibly removed from the nipple although they were fully furred at the time. Examinations were conducted at about weekly intervals from 144 days of age until 230 days by which time the young were difficult to handle and the operation became hazardous. The

young were also weighed and the shank measurements were taken. The growth rate of the teeth was determined from curves constructed from measurement data.

The degree of eruption of the teeth is indicated following the conventions adopted by Sharman et al (1964), namely Stage 1 - tooth just below the surface; Stage 2 - just erupting; Stage 3 - erupted, molars with all cusps just through the gum; Stage 4 - fully erupted.

The sequence of events and the measurements given are the average obtained for the four animals. No difference could be established in the rate of development of the teeth in the two sexes. One animal was about 10 days late in development and weight although born at the same time. This individual was a female melanic.

RESULTS

The age at which the teeth erupt is shown in fig. 1, which also shows the length of shank and the weight of the animal. The first teeth to appear are the I_2, followed by the I^2. These are first seen at Stage 1 at 135 days but do not erupt until 144 days of age. In general, the incisor teeth are the first to erupt and, with the exception of I^4, the incisor eruption is completed before the Stage 2 of the premolars which in turn precede the molars. The canine teeth appear before the completion of the molar sequence but usually after the appearance of M1 in both jaws.

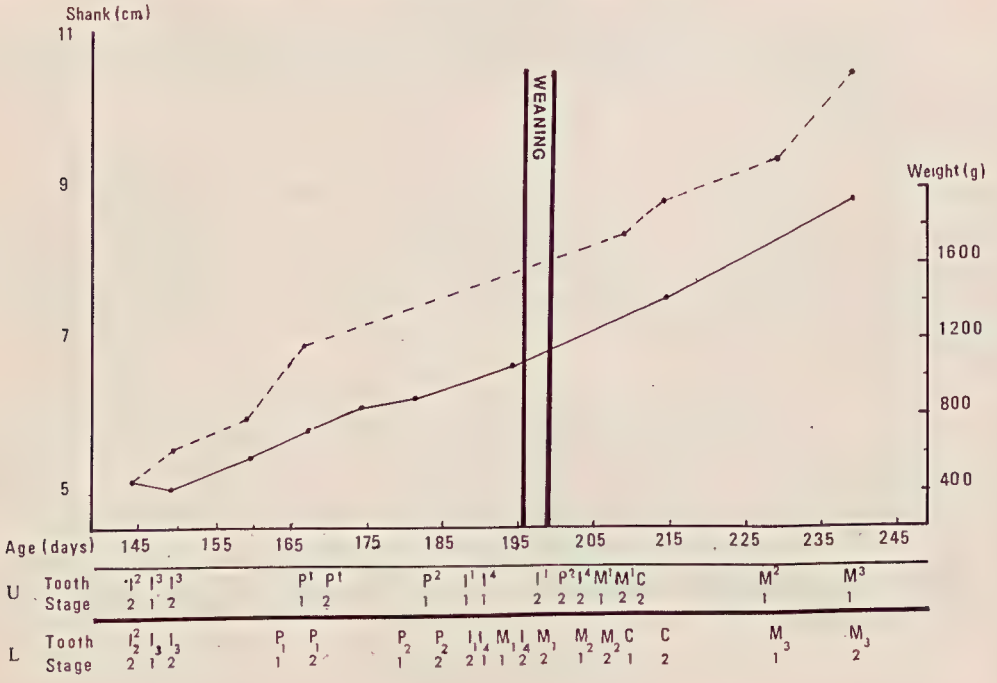

FIG. 1.- Sequence of eruption of the teeth in *Sarcophilus harrisii* in relation to weight, shank length and age. The lower curve shows the weight.

The I^1 do not appear as part of the normal front to rear eruption sequence of the incisor teeth, appearing later than I^2 and I^3, although the I_1 of the lower series follows very shortly after the appearance of I_3. The I4 series of both jaws is the last of the

pre-canine teeth to appear. The result of the late eruption of I^1 is that a gap is left in the upper incisor teeth at the antero-median part of the mouth.

The premolar and molar series follow in sequence, the canines appearing about the time of eruption of the last premolar and the first molar.

All of the I and C teeth appear first as conical pegs and do not assume their adult form for some 10-20 days. The P and M series appear in their adult tricusped condition, the anterior cusp being the first to erupt.

Considerable variation was found in the ages at which the teeth erupted in different individuals and the sequence of events changed from animal to animal. For example, the canine teeth may appear either before or after the eruption of the first molars.

The appearance of the various elements in the lower jaw usually preceded the eruption of their upper jaw counterparts by about five to seven days with the exception of I^1 which does not erupt until 40 days after I^3.

ERUPTION RATE OF THE TEETH

The eruption rate of the incisor teeth was about 0.05 cm every 20 days until the teeth reached normal juvenile size, though as with the eruption sequence there was considerable individual variation. The I^1 whenever they appeared did not grow at a more rapid rate than their predecessors. The eruption rate curve of the premolars was found to be the same as that of the incisors. Insufficient data was available to construct a growth curve for all the molars.

The eruption of the canine teeth of both jaws proceeds more rapidly than any of the other series, the rate being about 0.45 cm /20 days.

DISCUSSION

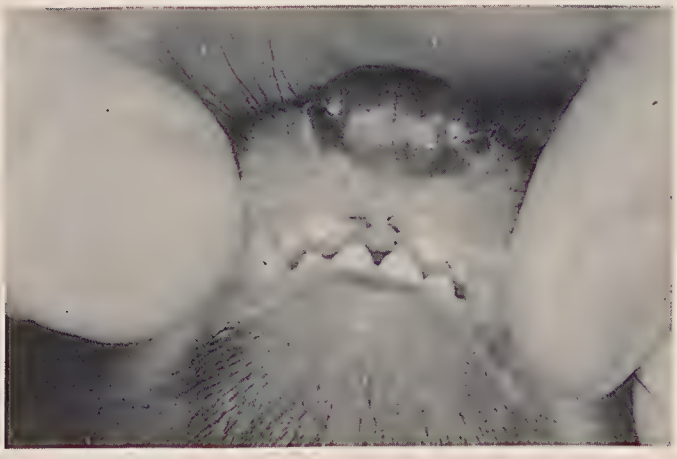

PLATE 1. - Juvenile *Sarcophilus harrisii*, aged 166±3 days, showing I_1 and I_2 also I^2 and I^3 with the gap soon to be occupied by I^1.

Young devils of the age of those described in this paper are not commonly available from zoological collections and have not been trapped in the wild during a seven year field study so that it hitherto has not been possible to establish some criteria for their age determination. The sequence of tooth eruption as described above together with the shank length and weight of the animal give a method of ageing devils for about 140 days after they become fully furred.

No evidence was seen of deciduous teeth such as occurs in some marsupials (Tate 1951), nor is there any evidence of a molar progression such as occurs in some adult macropods (Sharman *et al.* 1964).

The slow development of the I^1 of each side leaves a gap between the I^2 teeth. It was observed that when the nipple is being held by the young it passes through this gap. The young were kept under observation and found to be weaned by 200±5 days, the age at which I^1 erupted and I^4 also appeared. The teats of the mother regressed and the mammary

gland apparently ceased lactation by 208±5 days. Thus the eruption of I^1 is closely related to weaning and the evolutionary function assigned to the incisor gap by Thomas (1887) is untenable.

Field observations have shown that female devils captured in late November are not lactating and do not have any young keeping company with them. Thus, at this time, young devils must leave their mother and fend for themselves, being well equipped for this with a full set of incisors, canines, premolars and the first three pairs of molars. The food of these young devils is not known but it has been found that they are not attracted to traps containing meat bait and it would appear as if their feeding habits are somewhat different from those of the adult animal.

The amount of variation of eruption of the teeth between and within individuals makes this method of ageing unsuitable by itself for accurate age determination but when taken together with shank length and weight it offers a means of ageing young animals during their early independent life.

A drop in weight occurred in all four animals at about 150 days and may be associated with the onset of weaning, although completion of weaning was not noted until 45-50 days later.

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A NEW MIDDLE CAMBRIAN POLYMERID TRILOBITE FROM NORTH-WESTERN TASMANIA

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(with two text figures and one plate)

ABSTRACT

A new species of trilobite, *Pianaspis(?) leveni*, is described from the Radfords Creek Group, Dial Range Trough, north-western Tasmania. Its age is late Middle Cambrian, either of the *Lejopyge laevigata* II Zone, or the *L. laevigata* III Zone.

INTRODUCTION

The purpose of this paper is to describe a new species of polymerid trilobite, *Pianaspis(?) leveni* from the Radfords Creek Group of the Dial Range Trough, north-western Tasmania. The position of the fossil locality containing *Pianaspis(?) leveni* is shown in fig. 1. The sediments containing *Pianaspis(?) leveni* are those referred to by Banks (1956, p. 184) as "Argillite, with *Lejopyge* etc." Banks (1962) notes the presence of *Lejopyge laevigata* from the same locality. Burns (1964, p. 47) tabulated a succession from the same locality which he termed the Sugarloaf Gorge. *Pianaspis(?) leveni* comes from Unit 13 in the succession tabulated by Burns (*op. cit.*). Jago (1973, Table 2) recorded the following trilobites from Unit 13: *?Lejopyge laevigata* (Dalman), *Lejopyge laevigata armata* (Linnarsson), *Pseudophalacroma* (?) sp., *Ptychagnostus (Goniagnostus)* sp., *Hypagnostus* cf. *brevifrons* (Angelin), *Diplagnostus* sp., a species of new genus cf. *Clavagnostus* sp., and *Pianaspis(?)* sp. This faunal list indicates that the age of the fauna is late Middle Cambrian, either of the *Lejopyge laevigata* II Zone or the *L. laevigata* III Zone. Fossil groups apart from the trilobites are unknown from Unit 13.

Pianaspis(?) leveni is the species noted in Jago (1973) as *Pianaspis(?)* sp. It is significant in that it is the only polymerid trilobite known at present from Unit 13 despite intensive collecting. Further it is known only from one stratigraphic level. The palaeoecological significance of these and other factors in relation to the fauna of Unit 13 are discussed in Jago (1973).

The morphological nomenclature used below is that used in Moore (1959). The catalogue numbers refer to the collection of the Geology Department, University of Tasmania.

SYSTEMATIC DESCRIPTION

Superfamily PTYCHOPARIACEA Matthew, 1887

Family PAPYRIASPIDIDAE Whitehouse, 1939

Genus *PIANASPIS* Saito and Sakakura, 1936

Synonymy: See Chernysheva, 1970, p. 123.

Type species: *Pianaspis kodairai* Saito and Sakakura, 1936, p. 114, pl. 8, figs. 1-3.

Diagnosis: See Chernysheva, 1970, p. 124.

Discussion: Chernysheva (1970) reviewed *Pianaspis*. She placed *Tosotychia* Öpik in synonymy with *Prohedinia* Lermontova and Chernysheva and *Prohedinia* in synonymy with *Pianaspis*. Öpik (pers. comm.) agrees that *Tosotychia* is a junior synonym of *Prohedinia*.

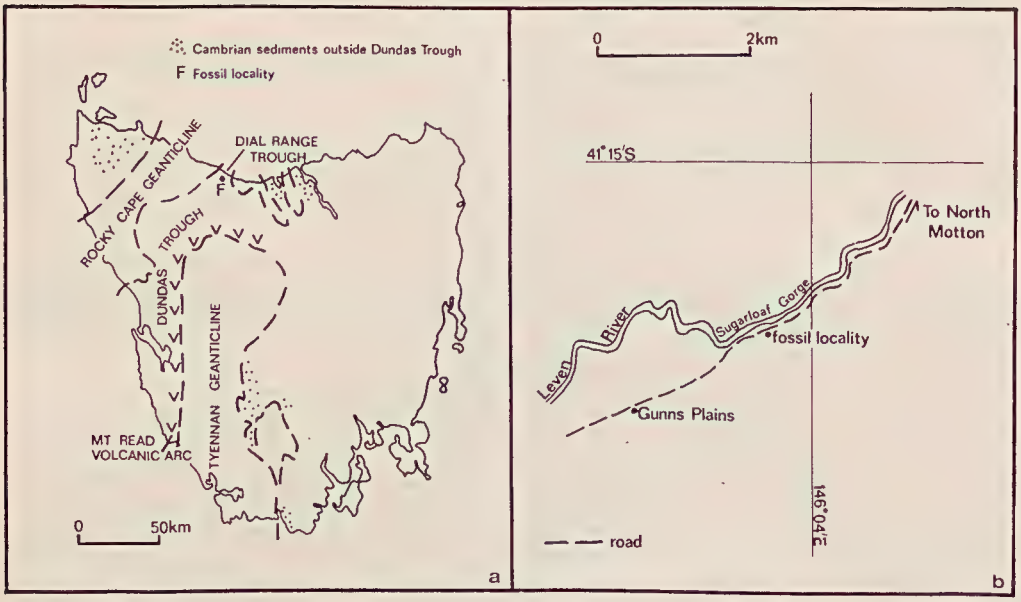

FIG. 1. - (a) Tasmanian Cambrian palaeotectonic framework (after Corbett *at al.*, 1972).
(b) Fossil locality in Sugarloaf Gorge on main road to Gunns Plains.

Chernysheva had at her disposal numerous examples of *Prohedinia attenuata*, the type species of *Prohedinia*, but had no specimens of *Pianaspis kodairai*. The photographs of *Pianaspis kodairai* shown in Saito and Sakakura (1936, pl. 8, fig. 1-3) are not particularly clear. It seems to me that Chernysheva should have obtained actual specimens of *P. kodairai* before placing *Prohedinia* (and thus *Tosotychia*) in synonymy with *Pianaspis*. Until such time as a detailed comparison of actual specimens of *Prohedinia atenuata* and *Pianaspis kodairai* is made, the synonymy of *Prohedinia* and *Pianaspis* is herein accepted with some reservations.

Öpik (1961, p. 148ff.) discussed the Papyriaspididae at length, especially the genera *Papyriaspis*, *Tosotychia (=Pianaspis)* and *Chancia*. He distinguished the Papyriaspididae from the Ptychopariidae on the single criterion that the former family has more than 16 thoracic segments. The form described below has an incomplete thorax (only eight segments preserved) and thus cannot be placed in either the Papyriaspididae or the Ptychopariidae on this basis. Öpik *(op. cit.)* placed the Papyriaspididae in the Ptychopariacea rather than in the Dikelocephalacea as was done in Moore (1959). Öpik's classification is followed here.

The cranidium is reasonably well preserved, and a combination of the characteristics of the cranidium and the thorax indicate that this form is related to *Pianaspis sors* (Öpik). Recorded differences are not considered great enough to distinguish it on a generic level from *Pianaspis sors*. However, the number of thoracic segments in the new species, *leveni*, is unknown, and thus it is only tentatively assigned to the genus *Pianaspis*.

Pianaspis (?) leveni sp. nov.

(pl. 1, figs. 1-12, text fig. 2)

Material: One almost complete cranidium, two partial cranidia (one of which is known as the internal mould), part of eight thoracic segments and one partial free cheek are reasonably well preserved. There are three hypostoma and a specimen with a partial cranidium and the two anterior thoracic segments. These are poorly preserved. There are also some isolated cranidial and thoracic segments. All specimens come from the one horizon, and because there are no other polymerids known from this section, all specimens are placed in the one species.

Measurements: Holotype cranidium (UT 92671), lengths, total 10mm; axial lobe, 7.1mm; preglabellar area, 2.9mm; widths, glabella (anterior), 3.8mm; glabella (posterior), 4.2mm; across palpebral lobes, 13.5mm. Thoracic segments (UT 92671), total length of the eight thoracic segments, 10.6mm. Hypostome (UT 92674) (pl. 1, fig. 8), exposed length, 3.2mm.

Selection of Holotype: The cranidium (UT 92671) (pl. 1, figs. 1-5) is chosen as the holotype.

Diagnosis: *Pianaspis(?) leveni* sp. nov. has a slightly tapered glabella, abaxially curved anterior facial sutures, gently curved posterior facial sutures, and prominent, narrow, elevated eye ridges. The anterior glabellar border is slightly to strongly elevated above the preglabellar field. There is a wide (tr.), narrow (sag.) plectrum. On the palpebral area of each fixed cheek, immediately adjacent to the palpebral lobe, is a low dome-like structure. The wide, deep almost straight posterior border furrow widens and deepens abaxially; the axial glabellar furrows are deep. Genal caeca are seen clearly only on the preglabellar field and on the frontal areas of the fixigenae. There is no occipital spine; there are no thoracic axial spines; the pleural spines are of moderate length.

Description

Cranidium: The cranidium is about twice as wide as is long. The axial lobe has a length about two-thirds that of the cranidium; it is quite convex and stands out well above the rest of the cranidium, which is either gently convex or gently concave. The fixed cheeks are wide; the palpebral areas of the fixed cheeks have about the same width as the glabella.

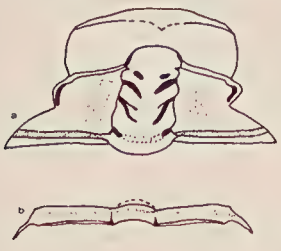

FIG. 2.- *Pianaspis(?) leveni* sp. nov. (a) cranidium based on Plate 1, figs. 1, 7 and 12. (b) thoracic segment (based on Plate 1, fig. 10). The slight distortion seen in the specimens from Sugarloaf Gorge is retained in the above figures.

From the posterior end of the palpebral lobes the posterior branches of the facial sutures diverge greatly. Close to the posterior end of each posterior branch, the facial suture has a very slightly convex (in an abaxial direction) outline. The centroanterior part of the posterior branches are almost straight; in the posterior part of the posterior branches they are curved strongly backwards.

The anterior sections of the facial suture are gently curved. From the anterior ends of the palpebral lobes the sutures diverge slightly up to a point about one-third of the distance to the marginal furrow; from this point they converge gently to the marginal furrow. On the anterior border the facial sutures converge strongly; each branch of the facial suture cuts the frontal margin a little over half-way to the median line from the points where they cut the marginal furrow.

The palpebral lobes, situated opposite the centre of the axial lobe, are poorly preserved in all specimens and have a length about 0.35 that of the glabella. They are gently convex and slope at a high angle into the wide, shallow palpebral furrows. The palpebral furrows are a continuation of narrow furrows which occur immediately to the posterior of the eye ridges throughout the entire length.

The narrow, elevated eye ridges are quite prominent. They appear to be single except in the adaxial region of the left hand eye ridge of UT 92671 (pl. 1, fig. 2) where there appear to be signs of a furrow between two separate ridges. They are directed slightly backwards from the glabella. The eye ridges are straight except at either end; the adaxial ends are curved forward and in the axial furrow the extreme ends of the ridges are almost parallel to the glabella; they meet the axial furrows just to the anterior of the most anterior glabellar furrows. The abaxial end of each ridge has a sharp backward bend in it before merging with the palpebral lobe. In this bend the elevation of the ridge is markedly increased.

The preglabellar field has a length about 0.2 that of the cranidium. The anterior border is slightly elevated in some specimens, but strongly elevated in others above the preglabellar field; it is separated from both the preglabellar field and the anterior area of the fixed cheeks by a shallow marginal furrow. The anterior border in its central region is slightly lower than it is abaxially. Across the preglabellar field the marginal furrow is deflected backwards to form a wide (tr.) but narrow (sag.) plectrum. The anterior areas of the fixed cheeks are gently convex and are highest posterolaterally. They slope gently down to the preglabellar field and the marginal furrow.

Immediately to the adaxial of the palpebral lobes, the palpebral areas of the fixed cheeks are strongly convex and form low dome-like structures. On the fixed cheeks (adjacent to the glabella) extending from near the 2p glabellar furrows to the posterior margin of the cranidium are low raised areas which widen backward and rise to a low maximum toward the posterior. Apart from these features the palpebral areas of the fixed cheeks are almost flat or slightly concave; these concave areas extend posteriorly across the posterior areas of the fixigenae to the posterior marginal furrows, becoming narrower and shallower to the posterior. The rest of each fixed cheek between this depressed area, the posterior branch of the facial suture and the posterior border furrow is almost flat except at the extremities where it slopes away.

The posterior border furrows are almost straight, wide and deep, becoming wider and deeper abaxially. The posterior borders are narrow becoming wider abaxially. On the fixed cheek there are small granules scattered over the surface.

The occipital ring is short (sag.), elevated and gently convex. The occipital furrow is wide and moderately deep being slightly deeper at the lateral extremities, which are directed strongly to the anterior. Overall the glabella tapers slightly forward; at its flatly rounded anterior end it has a width about 0.9 that at the posterior.

The glabella is outlined by narrow axial furrows which deepen to the anterior. The furrows are deepest where the eye ridges meet them. To the anterior of this point the furrows shallow markedly and only extend a little way around the front of the glabella.

There are four pairs of glabellar furrows. The most posterior pair (1p) meet the axial furrows about half way from the occipital furrow to the points where the eye ridges meet the axial furrows. They are deep, bifurcating and directed inward and very strongly backwards. The more posterior branches of the bifurcating pairs are much the deeper of the two; the posterior branches almost meet across the top of the posterior end of the glabella.

The second pair of glabellar furrows (2p) are directed inwards and backwards, but not as markedly as in 1p. They arise from about half way between where the eye ridges meet the axial furrows and the point where the 1p furrows meet the axial furrows. The 2p furrows are wide and deep but not as deep as the 1p furrows.

The third pair of lateral glabellar furrows (3p) occur as medium sized shallow depressions which do not reach the axial furrows. The fourth pair of lateral glabellar furrows (4p) occur as small indentations in the glabellar margin immediately to the posterior of where the eye ridges meet the axial furrows. The 3p and 4p furrows have a similar arrangement to that figured for the two anterior glabellar furrows of *Pianaspis sors* (Öpik) in Öpik, 1961 (fig. 50). Between the points where the eye ridges meet the axial furrows and where the 2p furrows meet these furrows the glabella appears to be slightly but distinctly expanded. This is especially evident in specimen UT 92671 (pl. 1, fig. 1). This feature does not appear to be present in UT 92673 (pl. 1, fig. 7). However, as UT 92671 is the better preserved specimen, it is considered that this feature is present in the species.

Genal caeca are seen clearly on the cranidium only on the preglabellar field and the frontal area of the fixigenae. The caeca have a reticulate pattern and are more prominent in front of the eye ridges than in front of the glabella where they are weak. In UT 92671 there is a very faint reticulation visible on the right hand palpebral area immediately to the posterior of the eye ridge. This cannot be seen in the photographs.

Free Cheek: Only one partially preserved free cheek is available. It is gently convex. The marginal region is poorly preserved, but there is a shallow, narrow marginal furrow and a border which is only slightly elevated above the furrow. There is a long genal spine as a continuation of the border. Genal caeca which radiate from the eye region are faintly visible.

Hypostome: No complete hypostome is available; most of the following description is based on the best preserved hypostome (pl. 1, fig. 8).

The strongly convex hypostome, when complete, is probably as wide (across the anterior wings) as is long. Most of the hypostome consists of the strongly convex median body. The border furrow is narrow and of moderate depth, except across the anterior and where it is shallow. The border is of moderate width. The anterior border is flat; the rest of the border appears to be convex and slightly elevated. The anterior wings are large, flat and triangular. Maculae are absent.

Thorax: The total number of thoracic segments is unknown. The most complete specimen of a thorax has only eight segments. The following description is based on these segments.

The axial region of each segment has a width about one-fifth that of the segment (including spines). The articulating device is not seen in any specimen. The axis is strongly convex. Across the anterior end of each segment there is a shallow concave furrow which narrows and deepens abaxially with small pits close to the axial furrows. The posterior part of the axis is slightly elevated and quite convex. Separating the axis from the pleurae are narrow axial furrows which have shallow axial sockets at the posterior and shallow anteriorly.

Each pleural segment is almost flat with a moderately deep pleural furrow which is directed abaxially and posteriorly. The furrow is close to the anterior margin adaxially, but in the abaxial third it tends to be close to the centre of the segment. It widens slightly abaxially, up to the base of the spine; the pleural furrows extend slightly into the base of the spine. Each spine is directed strongly to the posterior and is of moderate length. There is a gentle slope from the main part of the pleural segment down to the spine. The posterior flange is very narrow. There are no signs of pleural caecae.

Pygidium: This is unknown.

Discussion: *Pianaspis sors* (Öpik) is the best illustrated and described species of *Pianaspis*. For this reason *Pianaspis(?) leveni* is compared in detail with *P. sors*.

Pianaspis(?) leveni sp. nov. differs from *P. sors* in that it has no thoracic axial spines, and the pleural spines of *leveni* are decidedly longer than in *sors*. The genal spines in *leveni* are longer than those of *sors*. There is no occipital spine in *leveni* as there is in *sors*. The axial glabellar furrows of *leveni* are deeper than those of *sors*. In marked contrast to the situation in *sors*, there is very little sign of genal caeca to the posterior of the eye lines on *leveni* although this could be due to the preservation of *leveni*. The 1p and 2p furrows of *leveni* are directed more sharply to the posterior than in *sors*. The eye ridges in the latter are double whereas in *leveni* they appear to be single except in the case of UT 92671 mentioned in the description. *P. sors* has a posterior and an anterior parafrontal band; *P.(?) leveni* has neither of these features.

The anterior branches of the facial sutures of *leveni* diverge slightly to the anterior of the palpebral lobe and then converge in a smooth curve to the anterior marginal furrow. Those of *sors* are sub-parallel according to Öpik (1961, p. 162 and fig. 50). However, an inspection of the photographs of *P. sors* (Öpik, *op. cit.* pl. 15, figs. 1, 2, 3) indicate that they are somewhat convergent.

The glabella of *Pianaspis(?) leveni* is not as tapered as that of either *P. attenuata* or *P. sors* but is similar to *P. kodairai* in this respect. The 1p glabellar furrows of *P.(?) leveni* are directed more sharply to the posterior than are those of either *P. attenuata* or *P. kodairai*. The anterior cranidial border of *P.(?) leveni* narrows markedly in an abaxial direction as does that of *P. sors;* in both *P. attenuata* and *P. kodairai* there is little change in width along the anterior cranidial border. *P. sibirica* Solovjev differs from other species of *Pianaspis* in having a very narrow preglabellar field.

The writer agrees with Chernysheva (1970) that *Prohedinia brevifrons* Palmer (1968, p. 69, pl. 4, fig. 9) does not belong in *Pianaspis*. *Chancia palliseri* (Walcott) included by Palmer (1968, p. 69) in *Prohedinia* does not belong in *Pianaspis;* it has only two pairs of glabellar furrows (Rasetti 1951, p. 214) as compared with the four in *Pianaspis*. The cranidium, doubtfully assigned to *Chancia odarayensis* by Rasetti (1951, pl. 33, fig. 15) and included by Palmer *(op. cit.)* in *Prohedinia*, seems close to *Pianaspis*. This specimen, which has four pairs of glabellar furrows, appears to have a caecal pattern in front of the eye ridges (Rasetti, 1951, pl. 33, fig. 15) although Rasetti does not mention this in his description.

Occurrence and Age: *Pianaspis(?) leveni* sp. nov. comes from Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the road to Gunns Plains; its age is either of the *Lejopyge laevigata* II Zone or the *L. laevigata* III Zone.

ACKNOWLEDGEMENTS

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PLATE 1

Pianaspis(?) leveni sp. nov.

Figs. 1-5 UT 92671, holotype cranidium; fig. 1, dorsal view, x3.3; fig. 2, left anterolateral part of glabella showing eye ridge meeting glabellar furrow, x9; fig. 3, right posterolateral part of cranidium, x5.5; fig. 4, left posterolateral part of cranidium, x5.5; fig. 5, right anterolateral part of glabella showing eye ridge meeting glabellar furrow, x9.

Fig. 6 UT 92672, right librigena, x4.

Fig. 7 UT 92673, partial cranidium, x7.

Figs. 8, 9 UT 92674; fig. 8, hypostome, x9.4; fig. 9, hypostome, x11.3.

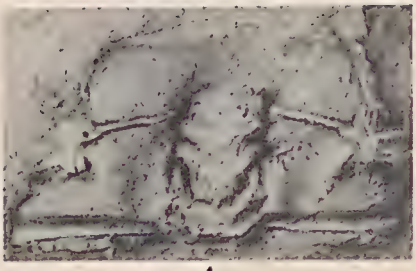
Fig. 10 UT 92671, part of eight thoracic segments, x3.8.

Fig. 11 UT 92675, poorly preserved cranidium plus anterior pair of thoracic segments, x11.5.

Fig. 12 UT 92676, internal mould of partial cranidium x5.

Except for the specimen in Fig. 12, all photographs are of rubber casts made from external moulds.

All specimens come from Unit 13, lower sedimentary sequence Radfords Creek Group, as exposed on the main road to Gunns Plains, lat 41° 16.1'S, long. 146° 03.7'E.



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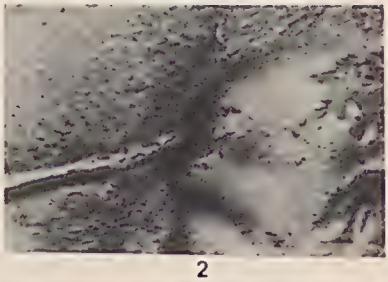

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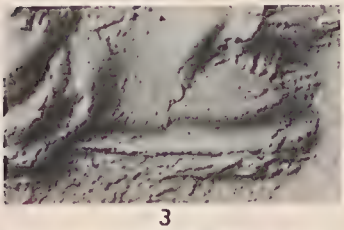

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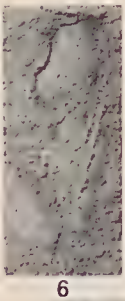

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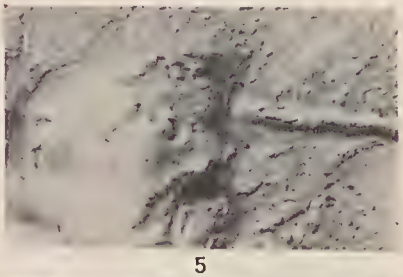

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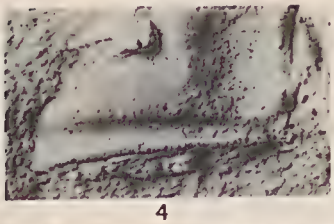

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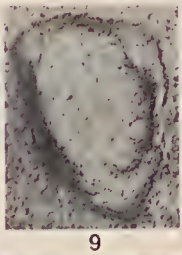

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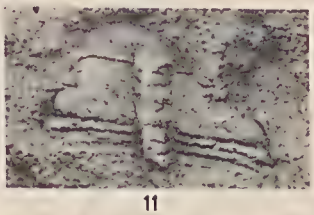

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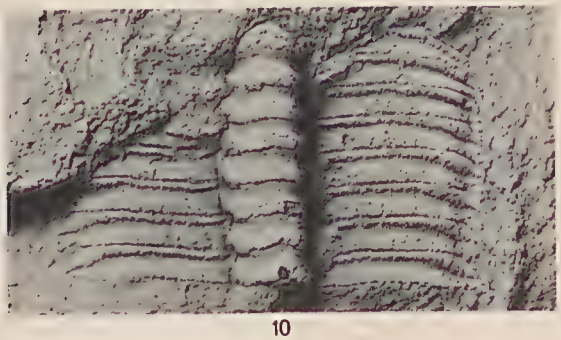

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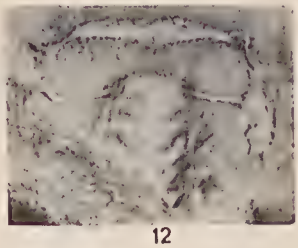

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PLATE 1

Papers and Proceedings of the Royal Society of Tasmania, Volume 108

(ms. received 25.9.1973)

THE LITTORAL ROCK FAUNA OF THREE HIGHLAND LAKES IN TASMANIA

by B.V. Leonard, Department of Applied Biology, R.M.I.T., Melbourne,

and B.V. Timms, Sciences Department, Avondale College, Cooranbong, N.S.W.,: both formerly Department of Zoology, Monash University.

(with one text-figure and three tables)

ABSTRACT

The littoral rock fauna of Dove Lake, Lakes Sorell and Crescent comprise 14, 26 and 20 species respectively. Within each lake the fauna varies greatly from rock to rock, but in general, rocks resting on stick or leaf litter harbor more individuals than those on rocks or pebbles. Between lakes there is an increase in biomass and a shift from dominance by insects to dominance by non-insects with increasing trophic status. Community structure of the littoral rock fauna in these lakes is compared to that in some European lakes.

INTRODUCTION

Prior to this study, the littoral rock fauna of only one freshwater lake in Australia had been studied. This lake, Lake Purrumbete in western Victoria, supports few species (Timms 1973) by European standards (Macan and Maudsley 1969; Hunt and Jones 1972) and the littoral rock fauna is dominated by non-insect forms. If Purrumbete is typical, then there is relatively low diversity in the littoral rock biocoenosis in Australian lakes, an aspect which Tillyard (1933) commented upon, but for which no quantitative data was presented. Furthermore, dominance by non-insect forms in Europe indicated lake enrichment (Macan and Maudsley 1969) and, since Purrumbete is strongly mesotrophic (Timms 1973), the same association could well apply in Australian lakes. Data on many other lakes is needed to test the validity of these suggestions.

The littoral rock fauna of Lakes Dove, Sorell and Crescent on the Tasmanian highlands were examined in mid-October 1972, with a view to :-

(a) documenting the types and numbers of species present on the littoral rocks and

(b) calculating standing crops of numbers and biomass and relating this data to lake trophic status.

THE LAKES

Dove Lake is deep (z_m = 60m (Benson 1917)) and lies at an altitude of about 910m in the northwest of the Central Highlands. Precambrian schists dominate the rocky shoreline, but there are also some glacially deposited stones composed of Jurassic dolerite and Permian sandstone.

Lake Sorell and Crescent are large and shallow, lying at an altitude of 820m near the eastern edge of the central plateau (Cheng 1972). About 75 percent of the shoreline is rocky in each lake and the rocks are of Jurassic dolerite.

METHODS

Sampling

Within each lake, stations with littoral rocks and covering approximately 10m of shoreline were arbitrary selected and the substratum type noted. Ten stations were sampled in Dove Lake (fig. 1) and five each in Lakes Sorell and Crescent. The stations

in Lake Sorell were in the vicinity of the Interlaken Guest House, and in Lake Crescent in the area just north of the Clyde River outflow.

At each station five rocks (10 in Dove) of manageable size (10 - 35cm long) were carefully removed, a net (mesh size 0.8mm) placed underneath and all the animals on the net and rock removed and preserved in 70% alcohol for later identification, counting and weighing. The dimensions of the undersurface of each rock were measured; they tended to be rectangular, and were assumed to be so in calculating their area.

Presentation of Data

In each lake there were large variations in numbers under each rock, and only in Dove Lake did the mean of numbers and biomass at each station exceed the variance. Thus 10 rocks are thought sufficient to characterize a station at Dove Lake, and so data are expressed as numbers and biomass per unit area of rock base per station. However, for Lakes Sorell and Crescent, since the means for each station are thought to be less reliable, data from the stations are combined as grand means for each lake to provide an order of magnitude.

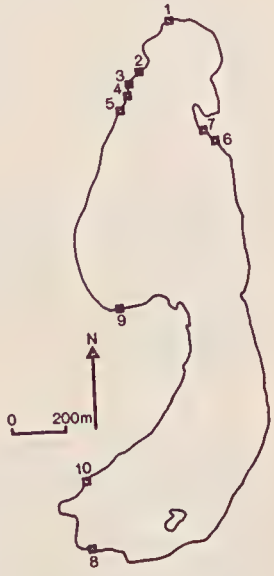

FIG. 1.- Dove Lake showing position of stations.

RESULTS

The relative abundance of each species in each lake is indicated in table 1. In Dove Lake, nine of the 14 species encountered were insects. One species of stonefly and one species of mayfly were especially prevalent, so that insects dominated the fauna, comprising 73 percent of total numbers. In Lakes Sorell and Crescent, the number of species and individuals were greater, and insects were not so important. Thus in Lake Sorell, 50 percent of the species were insects (13 out of 26 species), and in Lake Crescent only 40 percent (8 out of 20 species).

The numbers and biomass of each species per m^2 of rock base per station for Dove Lake are given in table 2. There was considerable variation between stations, and, although the variance between stations was smaller then the mean for all species combined, it approximated the mean when each species was treated separately. Numbers per rock was not correlated with rock size but rather with the nature of the substratum; in general, rocks resting on stick and leaf litter supported most animals and those on large stones, the least.

In Lakes Sorell and Crescent, variation both within and between stations was even greater, and in nearly all cases the variance exceeded the mean. The grand mean for all stations are given in table 3.

Although Dove Lake had the lowest number of individuals/m^2, biomass/m^2 was relatively high (table 3). In Dove, the dominant forms were large insects whereas in the other lakes the dominants were small in size, though in Crescent there were some large non-dominant species.

DISCUSSION

The most outstanding feature of the littoral fauna of each lake is the variability in numbers, and hence biomass, under each rock and between stations. For instance, in

TABLE 1

LITTORAL ROCK SPECIES AND THEIR RELATIVE ABUNDANCE IN DOVE LAKE AND LAKES SORELL AND CRESCENT.

	Species	Dove Lake	Lake Sorell	Lake Crescent
Turbellaria:	Triclad sp A ("striped")		++	++++
	Triclad sp B ("grey")	+	+	+
	Triclad sp C ("black")		++	++
	Triclad sp D ("big white")	+	++	+
Oligochaeta:	Unidentified sp. or spp.	+	++	+
Hirundinea :	Unidentified sp.			+
Crustacea :	*Austrochiltonia australia*		++	
	A. subtenuis			++++
	"Gammarus" australis	+		
	Neophargus cf *exiguus*			+
	"Pseudasellus"		+	++
	?Colubotelson thomsoni		+	++
	Paratya "tasmaniensis"		++	
Insecta :	*Atalonella delicatula*		++	
	Atalonella sp B			+
	Atalonella sp C	++		
	Eusthenia sp	++	+	++
	Leptoperla sp	+	+	+
	Cardioperla sp		++	
	Helicopsyche sp		+++	
	Caddis sp B (F. Leptoceridae)	+	+	+
	Caddis sp C (F. Psychomyiidae)	+		
	Sclerocyphon aquaticus	+	+	
	Simsonia sp		+	
	Platynectes decempunctatus			+
	Dytiscid larvae		+	
	Tabanid larvae		+	
	Limoniinid larvae	+	+	
	Orthoclad larvae sp A	+		
	Orthoclad larvae sp B	+		
	Orthoclad larvae sp C		+	+
	Ceratopogonid larvae		+	
Mollusca :	*Potamopyrgus niger*		+++	} ++
	Potomopyrgus sp B			
	Bulinus hainesii		+	+
	Gyraulus scottianus		+	
	Pisidium sp. near *casertanum*	+	+	+
TOTAL		14	26	20

Code + infrequent; ++ present; +++ abundant; ++++ very abundant.

TABLE 2

SUMMARY OF NUMBERS AND BIOMASS OF LITTORAL ROCK FAUNA IN DOVE LAKE

Station number	substratum	area of rocks m^2	number/m^2	wet biomass/m^2
1	large rocks	0.805	7.45	0.094
2	large rocks	0.567	22.93	0.140
3	pebbles on stick and leaf litter	0.561	41.00	1.423
4	large rocks	0.527	37.95	1.200
5	small rocks	0.506	23.72	0.443
6	pebbles	0.379	23.75	0.352
7	large rocks	0.488	24.59	0.185
8	rocks on stick and leaf litter	0.563	47.96	1.667
9	small rocks	0.278	50.36	0.360
10	rocks on stick and leaf litter	0.417	69.54	2.559
Mean			34.93	0.843
Variance			17.97	0.831

TABLE 3

RELATIONSHIP BETWEEN TROPHIC STATUS, STANDING CROP AND COMMUNITY STRUCTURE OF LITTORAL ROCK FAUNA.

	Trophic Status		Standing Crop/m^2		Community Structure	
	designation	primary production ($mgC/m^2/day$)	number	wet biomass	A	B
Dove	oligotrophic+	-	35	0.8	64	73
Sorell	oligotrophic	44.0+	770	0.5	50	43
Crescent	weakly mesotrophic	115.4+	600	1.5	40	7
Purrumbete	strongly mesotrophic	293.0ø	10,600ø	8.4ø	43	5

A - percentage of species that are insects

B - percentage of individuals that are insects

*R. Buckney (personal communication)

+from Cheng (1972)

øfrom Timms (1973)

Lake Sorell, one rock hid three individuals (one species), while an adjacent one had 23 individuals (11 species) under it.

This variability may be due to:-

(a) rock size - data from Dove Lake suggest that rock size within the range studied, is unimportant.

(b) the surface configuration of the rock or the degree of rugosity - many rocks contain pits and fissures that provide refuges for fauna. The importance of this is difficult to measure in the field.

(c) the percentage of the surface of rock in contact with the substratum.

(d) the underlying substratum type - there is definite evidence from all lakes that this is an important variable. Rocks on stick and leaf litter or on weed substrata harbour more animals than those on pebbles or rocks. There was also a tendency for fewer animals with increasing substratum particle size (table 2).

(e) the position of the station in the lake - In Dove Lake the two stations at the upper end of the lake had the highest biomass. This agrees with data on benthos for this lake (Timms, in prep.). Also, Macan and Maudsley (1969) showed variation in faunal abundance with position in a lake.

(f) depth below water surface.

(g) wave action in relation to prevailing winds.

Because of this variability, we suggest that many rocks per station and numerous stations per lake are needed to characterize the littoral rock fauna of a lake. On these criteria, the Dove Lake data are reasonably reliable, but those for Sorell and Crescent are not.

There have been numerous studies on the littoral fauna of European lakes but only two, those of Macan and Maudsley (1968, 1969), examine rock fauna alone. Since there are fewer species in the benthic faunas of Australian lakes than in those of the Northern Hemisphere (Timms 1973), the same may be true for the littoral rock fauna. Thus Lake Purrumbete, which was studied intensively, yielded 10 species of littoral rock insects (Timms 1973) whereas Lake Windemere in England supports 48 species of insects on littoral rocks (Macan and Maudsley, 1968). Also, although sampling was not intensive, the three Tasmanian lakes yielded a maximum of 13 littoral rock insect species in any one lake.

Macan and Maudsley (1969) show further that insects are generally more prevalent in numbers and species in unproductive waters, and are replaced by non-insects in enriched regions. To illustrate this we estimate from their data that only 0.5 percent of individuals (one out of 10 species) were insects at a eutrophic station in Lake Windermere, while at an ologotrophic station in the same lake, 70 percent of the fauna (eight out of 11 species) were insects. Much the same phenomenon is seen in the present Tasmanian lakes and in Lake Purrumbete. There is a moderate decrease in the proportion of insect species to non-insect species with increasing trophic status of a lake and a large decrease in the proportion when numbers of individuals are considered (table 3).

The relationship between the proportion of insect species and lake trophic status may not be as simple as portrayed. For instance, Dove Lake has been isolated since the retreat of the glacier from the area late in the Pleistocene and may not have received some less mobile forms. Also, Lake Purrumbete is about 2½ times more productive than Crescent, yet the insect/non-insect ratios are similar in each. Further, the Kosciusko lakes, which are oligotrphic, contain a relatively rich crustacean fauna as well as many insects (Knott, personal communication). Thus more data is still needed. However, it will be remarkable if the relationship is valid, for the faunas of the Northern and Southern Hemispheres have probably had dissimilar evolutionary histories.

Macan and Maudsley's (1969) figures also show that non-insects are especially numerous in highly productive waters. Likewise, our data reveal an increase in standing crop with increasing trophic status (table 3). The contrast between oligotrophic Dove Lake and strongly mesotrophic Lake Purrumbete is marked. This is despite the figure for Dove Lake probably being a seasonal peak, due to the dominant insects being largely in pre-adult instars.

ACKNOWLEDGEMENTS

We wish to thank Dr J. Martin of Melbourne University for field assistance, Miss J. Smith for biomass determinations and the following taxonomists for their identifications:- Mr B. Knott, University of Tasmania, Hobart (Phreatoicoidea); Mr A. Nebois, National Museum, Melbourne (Trichoptera, Coleoptera except Psephenidae); Dr B. Smith, National Museum, Melbourne (Mollusca); Dr W.D. Williams, Monash University, Clayton, (Crustacea except Phreatoicoidea): and Dr P. Zwick, Max Planck Institute, Schlitz, West Germany (Ephemeroptera, Plecoptera, Psephenidae).

We appreciate the comments by Dr P.S. Lake, University of Tasmania, on an early draft of the manuscript.

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Papers and Proceedings of the Royal Society of Tasmania, Volume 108

(ms. received 24.6.1974)

MECHANISM FOR MERCURY DEPOSITION AT NGAWHA SPRINGS, NEW ZEALAND

by H.A. Davey

Department of Geology
University of Tasmania

(with one text figure)

ABSTRACT

Elemental mercury is the source of mercury for current cinnabar deposition at Ngawha Springs, New Zealand. The deposition of cinnabar is strictly weather dependent for most of the area, occurring only during and just after rain. During these periods pH and Eh drop favouring oxidation of mercury at suitable sites; such conditions prove to be necessary and sufficient from laboratory experiments.

MERCURY DEPOSITION

Ngawha Springs, 250 km north of Auckland, is a site of present day cinnabar deposition (Davey and van Moort, 1974). This and other nearby deposits are associated with Tertiary and Quaternary hydrothermal activity. Small scale mining has taken place at Ngawha, but now balneal establishments have been erected adjacent to the ore deposits and fumaroles.

The springs are situated in a drained, insilted lake basin, below which is a chaos of marine sediments hundreds of metres thick (Fleming, 1945 and N.Z.G.S. Rept. 16, 1966). The area is surrounded by many Pliocene to Holocene basalt flows. It is probable that the present activity is associated with a shallow basaltic intrusion. The springs are up to 65°C, and do not discharge 'thermal' water. Heat is supplied by the ascending hot gases; composed of CO_2, CH_4, H_2O, NH_3, H_2S and Hg. The 'gas' to steam ratio is about 1,000 times that of Wairaki; thus it is dry by world standards.

Cinnabar is found in the hotter areas and coats various materials. It also occurs in stream sediments with sulphur, but is nowhere massive. During and after appreciable rain, but not at other times, cinnabar is conspicuously abundant in water courses, which also contain colloidal and freshly precipitated sulphur. The exposure of pyritic materials from the hot ebullient baths causes cinnabar coatings to appear in a couple of days.

During rainy periods Eh and pH generally drop markedly in most local waters, particularly where sulphurous gases percolate. In a period of drizzle, a pH less than 1.5 was recorded in the Ngawha Stream, normally with a pH of 4. Sufficiently high Eh's are present to cause formation of haematite and pyrolusite; i.e. Eh is more negative than -.9V for a pH of about 2 (Garrels and Christ, 1965).

The only detectable mercury species found coming into the area was elemental mercury. The major quantity is transported by gases at 35°C or more (fig. 1). The mercury concentration was saturation level in all gases found in the central active area. Most confined water associated with the gases were also saturated with mercury metal.

From the above observations and others, the deposition of mercury proceeds via oxidation in acid waters during rain, which supplies oxygen. There follows a fast reaction with dissolved sulphide present to yield metacinnabar (black) and cinnabar (red), to which the former soon changes. Laboratory simulation of the field conditions showed that the presence of air or oxygen was essential to the formation of cinnabar. Without air present no cinnabar could be formed even after several months, contrasting with the

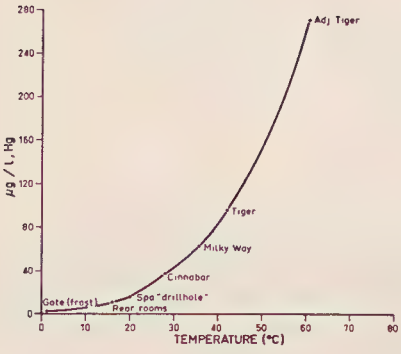

FIG.1.- The above points represent temperature and mercury concentration of thermal gases. The names are those of various balneal pools, or the approximate location. Gate (frost) refers to a sample collected from a small vent near the gate at the rear of the Spa hotel leading to the Tiger bath when the ground was covered in frost. Rear rooms' vent is at the south west corner of the Spa's western building; the Spa 'drillhole' is similarly located on the eastern building.

two days (max.) required at Ngawha during rain.

The standard electrode potentials are:

$$Hg^{++} + 2e^- \rightarrow Hg \quad + 0.851V \ (\varepsilon^o) \text{ and}$$

$$4H^+ + O_2 + 4e^- \rightarrow 2H_2O + 1.229V \ (\varepsilon^o)$$

Thus the reaction $2Hg + 4H^+ + O_2 \rightarrow 2Hg^{++} + 2H_2O$ is thermodynamically spontaneous, the standard e.m.f. being $\varepsilon^o = + 0.378V$.

The favoured 'mechanism' of transport deposition from alkaline sulphide solution (Krauskopf, 1951) is impossible in this case. There are no ascending waters and all waters present are acidic to almost neutral. The other major defect with the alkaline sulphide hypothesis is that it is cyclic. It assumes the pre-existence of cinnabar. Colloidal transport (Dickson and Tunell, 1968) is unlikely, as borehole waters (near the Ngawha Springs Hotel) contain only 0.00007 ppm total Hg, whilst surface waters, even in areas depositing cinnabar, have less than 0.03 ppm total Hg, all of which is elemental mercury.

ACKNOWLEDGEMENTS

Many thanks are due to the staff of the Geology Department, University of Auckland; particularly to Professor Brothers, Mrs. N. Howett and Mr. T. Wilson. Much assistance was also received from the entire Ginn family of Ngawha Springs. Dr. J.C. van Moort, University of Tasmania, provided much of the impetus necessary to start the project, and, Professor H. Bloom the laboratory equipment.

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Papers and Proceedings of the Royal Society of Tasmania, Volume 108

(ms. received 5.3.74)

THE LOCATIONS OF COLLECTION AND COLLECTORS OF SPECIMENS DESCRIBED BY LABILLARDIERE IN *'NOVAE HOLLANDIAE PLANTARUM SPECIMEN'* - ADDITIONAL NOTES.

by E. Charles Nelson

Department of Biogeography & Geomorphology, Australian National University, Canberra.

(with three tables)

ABSTRACT

Several plants described by Labillardière and indicated to have been collected in Tasmania are shown to be species endemic to Western Australia. The locations are corrected and collectors are indicated if the original specimens could not have been collected by Labillardière. The reasons for these errors are discussed and it is concluded that caution is required in accepting Labillardière's type locations.

INTRODUCTION

Jacques Julien Houtou de Labillardière visited the Australian and Pacific regions between 1791 and 1796. He was a member of the French expedition that was sent by *l'Assemblée Constituante* to search for the ships, commanded by La Pérouse, that had not been heard from since leaving Botany Bay in 1788. The search expedition was commanded by D'Entrecasteaux and was commissioned to conduct scientific investigation *en route*. Labillardière was on the expedition as a naturalist and therefore was able to make botanical and zoological observations and collections (Chevalier 1953, Stafleu 1966, Nelson in press). Labillardière published descriptions of some of his Australian [New Holland] plants between 1804 and 1807 in *'Novae Hollandiae Plantarum Specimen'*.

The author has already shown that certain plant specimens described by Labillardière in *'Novae Hollandiae Plantarum Specimen'* (1804) were incorrectly labelled in that volume and, in some cases, could not have been collected by Labillardière (Nelson in press). There is evidence available to show that some of the specimens were collected by Leschenault de la Tour (Nelson in press), who was a botanist on the French expedition, led by Baudin, that was in the Australian region between 1801 and 1803 (Cornell 1966).

That evidence concerned those specimens labelled *'Habitat in terra van-Leuwin'* by Labillardière and which were all allegedly collected in Western Australia at *Baie Le Grand* [Esperance Bay] (Labillardière 1800, 1804, Nelson in press). The investigations relating to the *'terra van-Leuwin'* specimens did not include the second and larger group of species that are labelled *'Habitat in capite van-Dieman'* [Tasmania]. Some of these latter specimens are discussed in this paper and similar conclusions concerning the locations of collections and the collectors can be reached as for the *'terra van-Leuwin'* species. A few of the specimens are incorrectly labelled *'capite van-Dieman'* (for easier comparisons with *'Novae Hollandiae Plantarum Specimen'* the ablative case is retained though the nominative case - *'caput van-Dieman'* should be used) as they could have been collected only in Western Australia, according to available information, or, in a single case, from New Caledonia. Some of these anomalous taxa were probably collected by Labillardière, but some of the species must have been collected by other botanists.

LABILLARDIERE'S VISITS TO TASMANIA

'Capite van-Dieman' refers to the areas on the island of Tasmania that Labillardière visited in the years 1792 and 1793 while he was a member of D'Entrecasteaux's expedition. The voyage of the ships commanded by D'Entrecasteaux has been discussed by

Stafleu (1966) and Nelson (in press). Accounts are available that were written by Labillardière (1800) and by another member of the expedition, Rossel (1808). A summary of the voyage of the vessels L'ESPERANCE and LA RECHERCHE is given below.

After leaving France in September 1791, the expedition sailed round the Cape of Good Hope and travelled east towards Australia [New Holland]. In April 1792 the ships dropped anchor in *Baie de l'Aventure* on the south-east coast of Tasmania. Here Labillardière made his first Australian collections. After visiting several other places in Tasmania, the vessels sailed north along the east coast of Australia to New Caledonia and the islands of the New Guinea region. Then they voyaged into the Indian Ocean and eventually reached Western Australia, at Cape Leeuwin, in December 1792. The ships sailed east along the south coast of the continent and anchored in *Baie Le Grand* [Esperance Bay]. It was in the environs of *Baie Le Grand* that Labillardière collected the specimens that are labelled *'terra van-Leuwin'* (Labillardière 1800, 1804, Nelson in press). Leaving this area on 18 December 1792, the ships sailed direct to Tasmania where Labillardière expanded his *'capite van-Dieman'* collections before the expedition left Tasmania, once again, and journeyed to the New Guinea region, without calling at any place on the east coast of Australia.

The ships eventually reached Java where the republican scientists and members of the crew were detained by the Dutch authorities; Labillardière was among those arrested. Rossel, however, persuaded the Dutch to allow him to return to France on a Dutch ship, and he took with him Labillardière's biological specimens. Before reaching its destination the ship bearing Rossel was captured by the English and the collections were taken to London. Banks later secured the return of the collections to Labillardière in 1796 (de Beer 1960).

In 1804, Labillardière published the first part of his flora, *'Novae Hollandiae PlantarumSpecimen'*, and this contained descriptions of many of his Australian specimens. Stafleu (1966) indicated that Labillardière worked on his own specimens only, but it can be shown that he had access to other collections, particularly those of Leschenault (Nelson in press). The plants collected in Tasmania were labelled *'Habitat in capite van-Dieman'*, while those collected in Western Australia were labelled *'Habitat in terra van-Leuwin'*. It is known that *'terra van-Leuwin'* referred to one area - *Baie Le Grand*. While in the Australian area Labillardière did not collect at any locations other than at *Baie Le Grand* and in Tasmania. He did collect on New Caledonia, and specimens from that island are labelled accordingly. Most of the New Caledonian specimens are described in a separate volume (Labillardière 1824).

TASMANIAN FLORA: HISTORY AND COMPOSITION

While Labillardière was not the first botanist to make collections on Tasmania, his specimens did include some previously undescribed species. Prior to Labillardière, collections had been made by Johann and Georg Forster in 1773 and by Nelson and Anderson in 1777. These collectors were on separate expeditions led by Cook (Hooker 1860, Maiden 1908). Extensive collections were sent to Banks by various collectors following the establishment of penal colonies by the English in New South Wales and on Tasmania in the latter part of the eighteenth century (Hooker 1860).

Both Brown (botanist on Flinders' expedition) and Leschenault (on Baudin's expedition) made collections on Tasmania in the early part of the nineteenth century. Collection was greatly increased in the following years due to the arrival of resident botanists on the island. In 1840, Tasmania was visited by Hooker, who was the surgeon-botanist on Ross' expedition with the ships EREBUS and TERROR. Hooker's account of the flora of Tasmania (1860) includes his very perceptive introductory essay. Charles Darwin also visited Tasmania, while on the voyage of the BEAGLE in 1836 (Darwin 1839; Hooker 1860; Moorehead 1969; Marshall 1970), but made no collections there.

TABLE 1

EARLY BOTANICAL INVESTIGATIONS IN TASMANIA, UP TO THE PUBLICATION OF LABILLARDIÈRE'S FLORA.

Date	Collector	Remarks
1773	Johann R. FORSTER J. Georg A. FORSTER Andrew SPARMANN	Sparmann and the Forsters (father and son) were on Cook's second voyage. They collected at Adventure Bay (Tasmania); the bay was named after Furneaux's vessel 'ADVENTURE'.
1776	David NELSON William ANDERSON	These botanists were on Cook's third voyage and collections were made in Tasmania.
1792-1793	J.J.H. de LABILLARDIÈRE	Collected at Storm Bay on two occasions during D'Entrecasteaux's voyage.
1802	Robert BROWN LESCHENAULT de la Tour	Botanist with Flinders. Botanist with Baudin.
1804	William PATERSON	Lieutenant-Governor of Tasmania; he sent specimens to Banks.
1804-1807	NOVAE HOLLANDIAE PLANTARUM SPECIMEN	published.

The Tasmanian flora includes endemic species and genera, and is generally regarded as containing many primitive relict elements derived from a Gondwanaland flora. The Tasmanian flora does not exhibit as high a rate of endemism as the flora of south-western Western Australia (Burbidge 1960). Having studied the flora and its relationships with the florae of other areas, Hooker (1860) was led to suggest that the distribution patterns and evolutionary relationships could only indicate "that the three southern Floras, the Antarctic, the Australian and the South African.....may all have been members of one great vegetation which may once have covered..a southern area, and.. the geographical changes that have resulted in its dismemberment into isolated groups scattered over the Southern Ocean, must have been great indeed".

However, using the available information on species distributions it is possible to examine Labillardière's species to ascertain the origin of certain taxa that do not appear to be correctly labelled.

SPECIES LABELLED *'HABITAT IN CAPITE VAN-DIEMAN'*

The methods used in this investigation are the same as those employed in the survey of the *'terra van-Leuwin'* species (Nelson in press). All the angiosperm specimens labelled *'Habitat in capite van-Dieman'* were listed and the nomenclature was revised to correspond to present usage. The distribution patterns of the taxa were determined using available literature. Those species that were anomalous and which do not occur in Tasmania today, according to available data (Curtis 1956, Willis 1972), were noted and further details of their distribution patterns were ascertained. These taxa are discussed below and listed in table 2.

Locality and Collector of Labillardière's Plant Specimens

Labillardière's own herbarium specimens only bear the name and occasionally the draft of the description, published in *'Novae Hollandiae Plantarum Specimen'*, in his handwriting. They do not normally bear any indication of the collector (other than handwriting) or the date and location of the collections. Thus if a name or location is attached the specimen is probably not one that was collected by Labillardière, especially if the location is not known to have been visited by Labillardière (Steinberg pers. comm., Nelson in press).

COLLECTOR AND LOCATION OF COLLECTION OF ANOMALOUS SPECIES

A full list of these species with details of their distribution, according to present knowledge is given in table 2. The species are discussed below. None of these species grows wild in Tasmania today.(Curtis 1956).

TABLE 2

DISTRIBUTION OF ANOMALOUS SPECIES LABELLED *'capite van-Dieman'*. Districts (in brackets) after Western Australia refer to south-west province (Beard 1970, Nelson in press) except where Eremean zone is indicated.

tom.	page	tab.	Present nomenclature [basionym if different]	Distribution (Willis 1972, Beard 1970)
ii.	39	182	*Helichrysum cinerum* (Labill.) F. Muell ex Benth. [*Chrysocoma cinerea* Labill.]	(New Caledonia)
ii.	73	223	*Adriana quadripartita* (Labill.) Gaudich. in Freyc. [*Croton quadripartitum* Labill.]	Victoria and Western Australia (Irwin, Darling, Stirling, Eyre).
ii.	29	170	*Astartea fascicularis* (Labill.) DC. [*Melaleuca fascicularis* Labill.]	Western Australia (Darling, Stirling, Avon)
i.	88	114	*Frankenia tetrapetala* Labill.	Western Australia (Stirling, Eremean zone - Coolgardie)
i.	106	134	*Gompholobium tomentosum* Labill.	Western Australia (Stirling, Irwin, Avon, Darling)
i.	17	16	*Lepidosperma squamatum* Labill.	Western Australia (Darling, Warren)
i.	11	-	*Pimelea clavata* Labill.	Western Australia (Stirling, Warren)
i.	56	80	*Scaevola cuneiformis* Labill.	Western Australia (Eyre)
i.	23	29	*Stipa elegantissima* Labill.	Victoria, South Australia, Western Australia, (Irwin, Darling, Warren, Stirling, Eremean zone - Austin, Coolgardie)
i.	65	90	*Sollya heterophylla* Lindl. [*Billardiera fusiformis* Labill.]	Western Australia (Darling, Stirling, Eyre)
ii.	86	235	*Acacia saligna* (Labill) Wendl. (*Mimosa saligna* Labill)	Western Australia (Eyre) (Maslin in press)
ii.	9	147	*Leptospermum sericeum* Labill.	Western Australia (Cape Le Grand only)

i. *Helichrysum cinereum* (Labill.) F. Muell. ex Benth. (basionym:*Chrysocoma cinerea)*

The identity of the species described by Labillardière was confused for a considerable time. Hooker (1860) referred it to *Ozothamnus cinerea* R.Br. stating that Labillardière's specimen differed from that supplied by a later collector, Gunn, "only in rather shorter leaves.." Wakefield later indicated that Labillardière's specimen must be of New Caledonian origin, and was not Tasmanian (Wakefield 1951, 1954, Burbidge 1958). Labillardière did collect in New Caledonia.

ii. *Adriana quadripartita* (Labill.) Gaudich. in Freyc. (basionym:*Croton quadripartitum)*

This species occurs in Victoria (Willis 1972) and in Western Australia (Bentham 1863, Blackall and Grieve 1954, Beard 1970). Weston (pers.comm.) has collected this plant at Esperance. It exhibits a disjunct distribution pattern that is occasionally found in southern Australia, when a species is apparently absent from the southern-central regions of the continent; in particular on the Nullarbor Plain (Green 1965). The species has been confused with *A. klotzchii* (F. Muell.) F. Muell. which is found in South Australia and it is possible that more detailed taxonomic studies are required on this particular taxon to establish its exact nature.

Assuming the present nomenclature to be correct and the distribution patterns to be accurate, the species occurs in southern Victoria (Willis 1972) and in Western Australia from the Irwin district to the Eyre district of the south-west province (Beard 1970). Bentham (1863) listed "Tasmania - Labillardière" as one of the collections. Hooker (1860) did not list the species at all. It would appear to be incorrect to assume that Labillardière collected the species in Tasmania as it is not found there today (Curtis 1956) but it is possible that he collected the species at Baie Le Grand in Western Australia; thus the specimen should probably have been labelled *'terra van-Leuwin'*.

iii. *Astartea fascicularis* (Labill.) DC. (basionym:*Melaleuca fascicularis).*

This species is found today in the Darling, Stirling and Warren districts of Western Australia (Beard 1970). Bentham (1863) listed specimens from the Murchison River to Lucky Bay, east of Cape Le Grand on the eastern side of Baie Le Grand [Esperance Bay]. Bentham indicated several early collections including Labillardière's; "King George Sound, Lucky Bay - Brown, Labillardière". He made several comments on the nature of Labillardière's specimen, stating that it represented a coarse form of the species with leaves less clustered than in other material. He did not doubt the identity of Labillardière's specimen nor the description. Bentham (1863) assumed the location of collection to have been in Western Australia, though he did not discuss the label *'capite van-Dieman'* used in *'Novae Hollandiae Plantarum Specimen'* (Labillardière 1804).

As early as 1844 it was recognised that there had been an error in the location of collection given by Labillardière. In *'Plantae Preissianae'* (Lehmann 1844) the species is described and the description includes the statement: *"In terra van-Leuwin: Labill. sic enim certo legendum pro loco, lapsu memoriae allato Prom. Van-Dieman".* Thus the error was noted and corrected and this was repeated by Hooker (1860) who said "stated by Labill. to have been found in Tasmania, is not so, but a native of South-western Australia". Both these statements are corroborated by data on the distribution of the taxon, and it can be said that Labillardière was in error in his flora. He could have collected the species at Baie Le Grand and thus should have used the label *'terra van-Leuwin'*. The species has been collected at Esperance recently (Weston pers.comm.).

iv. *Frankenia tetrapetala* Labill.

According to extant data this species is found in the Stirling district and in the Coolgardie district of Western Australia (Beard 1970). Bentham (1863) listed specimens from King George Sound and "south coast".

With reference to Labillardière's specimen, Bentham stated that it was "said to have come from Tasmania; but there is very likely to have been some mistake.... there is no doubt about the identity" of the specimens. Hooker (1860) said "Labillardière figures *F. tetrapetala* as a native of Tasmania. It much resembles a Western Australian plant..." This species appears to have been incorrectly labelled *'capite van-Dieman'* by Labillardière (1804); he probably collected the material at Baie Le Grand - *'terra van-Leuwin'*. Summerhayes (1928) revised the Australian members of this family and corrected the type location.

v. *Gompholobium tomentosum* Labill.

This plant is confined to Western Australia and is found in areas south of the Murchison River (Bentham 1863, Beard 1970). It does not apparently occur near Baie Le Grand. The author has collected it within 100 km of that bay.

Bentham does not comment on the distribution of the species but he does list Labillardière's specimen as coming from King George Sound, which is not possible, as Labillardière never visited the Sound (Nelson in press). Hooker (1860) stated that the species "is erroneously described as a native of Tasmania in De Candolle's *Prodromus*". It is also erroneously described thus in Labillardière's flora (1804). The species must have been collected in Western Australia and it is not improbable that the specimens used by Labillardière were collected by Leschenault at King George Sound as the species is absent from the environs of Baie Le Grand today.

vi. *Lepidosperma squamata* Labill.

There has been considerable confusion about the nomenclature of the material that Labillardière described, mainly because of the location given for the species in *'Novae Hollandia Plantarum Specimen'* (Labillardière 1804). Bentham did not list the species but referred to it in a note on another species. He stated that Labillardière's specimens appeared to represent *"L. angustatum* R.Br.; a Western Australian form only". A similar conclusion was reached by Hooker (1860). Thus, the label in Labillardière's flora may be regarded as incorrect. The species is found in the Darling and Warren districts of Western Australia today (Beard 1970), and the specimens that Labillardière used most probably were collected by Leschenault.

vii. *Pimelea clavata* Labill.

This Western Australian endemic species is found in the southern coastal areas of the region from Augusta to the Fitzgerald River in the Stirling and Warren districts (Bentham 1863, Beard 1970). Neither Bentham (1863) nor Hooker (1860) comment on the location of Labillardière's collection. However in a footnote in 'Botanical Magazine' in a section on *P. ligustrina* Labill. (*P. hypericina* Cunn.) the following comments are found: "Another, and even rarer species in the English gardens has been in flower during the last spring at Kew. It proved to be *Pimelea clavata* Labill., a plant originally discovered, many years ago, in Van Dieman's Land, and afterwards observed on the south coast of N. Holland by Mr. Brown; and from the desert native shores of others of its kindred, King George's Sound, was introduced to the Royal Gardens in 1823". The author of the note is uncertain though the main description (of *P. hypericina*) is attributed to Allan Cunningham (1834, t.3330.)

This would appear to indicate, when considered with extant data, that Labillardière's location was an error and that the label should have read *'terra van-Leuwin.* However the present distribution of the species would indicate that Labillardière could not have collected the species himself, at Baie Le Grand, and thus the material must have been obtained elsewhere by another collector, probably at King George Sound.

viii. *Scaevola cuneiformis* Labill.

This species in confined today to the Eyre district of south-west Australia, and the taxon is common around Baie Le Grand. Labillardière would have been able to collect the species when he visited that area, though he indicated that the specimen came from *'capite van-Dieman'*. Hooker (1860) stated that the taxon, while "described by Labillardière as a Tasmanian plant is probably a native of south-western Australia". Bentham (1863) repeated this and he was able to indicate that the figure and description given (Labillardière 1804) left no doubt about the identity of the material despite the stated location of collection.

ix. *Stipa elegantissima* Labill.

This species is very widespread in southern Australia but it is absent from Tasmania (Curtis 1956). It occurs in Victoria (Willis 1972) and in South Australia (Black 1924), as well as in Western Australia (Beard 1970). Bentham (1863) stated that Labillardière's specimen from Capt. Baudin in Herb. Brown, is, however, marked 'Nouv. Hol. Sud-Oeust'. Hooker (1860) made this statement; "*S. elegantissima* is stated by Brown (Prodromus 175) (1810) on authority of the late Mr. Lambert's herbarium to be a native of Tasmania. It is a native of South-Western Australia and Swan River...".

The absence of the species from Tasmanian collections (Bentham 1863, Curtis 1956, Willis 1972) and the data on present distribution patterns indicates that Labillardière could not have collected the taxon in Tasmania. The statement of Bentham (1863) that Labillardière's specimen was from Baudin, indicates that the species was not collected by Labillardière but by Leschenault. The location of the collection - Nouv. Holl. Sud-Oeust - could be either Geographe Bay or King George Sound, which are both situated within the distribution range of the species. Bentham's indication that the material was obtained by Baudin's expedition confirms the use of material collected by other French botanists by Labillardière (Nelson in press).

x. *Sollya heterophylla Lindl.* (synomym: *Billardiera fusiformis* Labill.)

This blue-flowered climbing plant is found in Western Australia only; in the Darling, Stirling and Eyre districts (Beard 1970). Bentham gave Labillardière's collection location as King George Sound, which is incorrect. In *'Plantae Preissianae'* (Lehmann 1844) Putterlich stated *"Crescit in Australiae insulae Van-Dieman* (Jan. 1793. Labillardière ex sched. specim. authent.)". While Bentham makes no comment on Labillardière's specimen, apart from giving an incorrect location, Hooker (1860) does make a most interesting and significant statement. Hooker said, in a preamble to the genus: "Endlicher says that the genus *Sollya (Billardiera fusiformis* Labill. of south west Australia) is also found in Tasmania; but I know of no species from that country. Putterlich also (Pl.Preiss, 203) [quoted above in latin original] says that he has examined an authentic specimen of Labillardière's gathered in Tasmania in January 1793. Both statements probably arise from some errors that are known to have crept in Labillardière's localities."

In an entry in the Tasmanian Journal of Natural Science requesting information on biological matters the following was found: *"Solbya angustifolia* [should read *Sollya*] - Has any botanist in the island collected *Solbya angustifolia (Billardiera fusiformis* Labill.). It is a blue-flowered species of climber and stated to be an inhabitant of Van Dieman's Land." (Anon. 1842).

All these statements, when considered with extant data on the genus' distribution, indicate that Labillardière must have been incorrect in labelling the species *'capite van-Dieman'*. He could have collected the species at Baie Le Grand: the species is found there today.

xi. *Leptospermum sericeum* Labill.

Curtis (1956) included this species in the Tasmanian flora, but it has since been reassessed and the taxon endemic to Tasmania is *L. glaucescens* Schauer (Willis 1967). The species described by Labillardière is a Western Australian endemic that is restricted to the granite monadnocks of the Cape Le Grand region, where Labillardière made his collections in 1792. It is certain that Labillardière collected this species so the location should have read *'terra van-Leuwin'*.

xii. *Acacia saligna* (Labill) Wendl. (basionym; *Mimosa saligna)*

The status of this species has been discussed by Maslin (in press) and he has pointed out the error in the type location. Labillardière collected the type specimen himself as it bears his autographic description and the taxon is a Western Australian species, not Tasmanian. The location given by Labillardière is in error, it should be *'terra van-Leuwin'*. Labillardière (1804) incorrectly indexed *A. saligna* as *"Mimosa salicina"*; the latter epithet is a valid epithet for another species *A. salicina* Lindl.

xiii. *Pultenaea dentata* Labill.

This taxon has already been discussed in detail in the paper on Labillardière's *'terra van-Leuwin'* plants (Nelson in press). It was labelled *'terra van-Leuwin'* in *Novae Hollandiae Plantarum Specimen'*, but should have been labelled *'capite van-Dieman'* (Labillardière 1804, Nelson in press) as it is not found in Western Australia (Beard 1970). Hooker (1860) stated with reference to this species; "This agrees so well in most respects with Labillardière's figure and description that I can hardly doubt it being his plant, though that is described as coming from *'Terra van-Leeuwyn'*."

DISCUSSION

Hooker's statement that "errors are known to have crept into Labillardière's localities" is most significant [see *Sollya heterophylla* above]. It indicates that he recognised that care was needed in dealing with localities quoted by Labillardière.

The problem arises from the fact that Labillardiere did not put the location of collection on his specimens. They bear the name used in *'Novae Hollandiae Plantarum Specimen'* and sometimes the page of the description, the plate number or the autographic description in Labillardière's handwriting (Steinberg pers. comm.). When this is recognised there is little difficulty in identifying Labillardière's personal specimens, assisted by comparisons of the handwriting. Burbidge (1958) states "At Kew there is a specimen from Herbarium Hookerianum with a label *"Chrysocoma cinerea* t 182" *(Helichrysum cinereum)*. There is nothing to indicate that this is from Labillardière's herbarium but the quotation of the original plate may be significant." The lack of information on the herbarium sheet other than the name and plate number, would appear to indicate that this specimen was from Labillardière's herbarium. Specimens of Labillardière's from Herbarium Webbianum in Firenze(FI), similarly, bear no name or location (though this is often added in different handwriting).

Hooker (1860) corrected most of Labillardière's errors when they referred to Tasmanian species; all the species discussed above, when mentioned by him, bear a statement correcting the location of the collection. Bentham (1863) also used the corrected location but occasionally gives Labillardière's collecting area as King George Sound. Labillardière did not visit that area, so that either that location is incorrect or another collector was responsible for making the collection at the Sound. In the case of *Stipa elegantissima* and *Pileanthus limacis* the material was collected on Baudin's voyage, probably by Leschenault, either at King George Sound, Geographe Bay or Shark Bay (Nelson in press). Later authors have recognised errors, but no attempt has been made to assess the Labillardière specimens as a unit.

TABLE 3

SUMMARY OF COLLECTORS AND LOCATIONS OF COLLECTIONS OF ANOMALOUS SPECIES described by Labillardière in *'Novae Hollandiae Plantarum Specimen'* (1804) - *capite van-Dieman* and *terra van-Leuwin* (Nelson in print); capite van-Dieman = Tasmania; terra van-Leuwin = Baie Le Grand (Esperance Bay) Western Australia.

Species [basionym]	Labillardière's location	corrected location	Collector
Adriana quadripartita (Labill.) Gaudich. in Freyc.	capite van-Dieman	Western Australia	Labillardière
Astartea fascicularis (Labill.) DC.	capite van-Dieman	Western Australia	Labillardière
Frankenia tetrapetala Labill.	capite van-Dieman	Western Australia	Labillardière
Gompholobium tomemtosum Labill.	capite van-Dieman	Western Australia	? Leschenault
Lepidosperma squamatum Labill.	capite van-Dieman	Western Australia	? Leschenault
Pimelea clavata Labill.	capite van-Dieman	Western Australia	? Leschenault
Scaevola cuneiformis Labill.	capite van-Dieman	Western Australia (Esperance)	Labillardière
Stipa elegantissima Labill.	capite van-Dieman	Western Australia	Leschenault
Leptospermum sericeum Labill.	capite van-Dieman	Western Australia (Esperance)	Labillardière
Acacia salicina (Labill.) Wendl.	capite van-Dieman	Western Australia (Esperance)	Labillardière
Helichrysum cinereum (Labill.) F. Muell ex Benth.	capite van-Dieman	New Caledonia	Labillardière
Knightia strobilina Labill.	terra van-Leuwin et Nova-Caledonia	New Caledonia only	Labillardière
Pultenaea dentata Labill.	terra van-Leuwin	Tasmania	Labillardière
Eucalyptus ovata Labill.	terra van-Leuwin	Tasmania	Labillardière
Actinotus helianthi Labill.	terra van-Leuwin	New South Wales	? Lahaie
Platysace lanceolata (Labill.) Norman	terra van-Leuwin	New South Wales	?
Pileanthus limacis Labill.	terra van-Leuwin	Shark Bay, Western Australia	Leschenault
Stylidium glaucum Labill.	terra van-Leuwin	? King George Sound Western Australia	? Leschenault
Stylidium spinulosum R.Br. [*Stylidium setaceum* Labill.]	terra van-Leuwin	? King George Sound Western Australia	? Leschenault
Cephalotus follicularis Labill.	terra van-Leuwin	King George Sound Western Australia	Leschenault

Locality and Collector of Labillardière's Plant Specimens

TABLE 3 (continued)

Species [basionym]	Labillardière's location	corrected location	Collector
Adenanthos obovata Labill.	terra van-Leuwin	King George Sound Western Australia	Leschenault
Anthocercis littorea Labill.	terra van-Leuwin	probably correct	Labillardière
Thomasia triphylla (Labill.) Gay	terra van-Leuwin	probably correct	Labillardière
Opercularia spermacocea Labill.	terra van-Leuwin	probably correct	Labillardière
Opercularia apiciflora Labill.	terra van-Leuwin	probably correct	Labillardière
Lobelia heterophylla Labill.	terra van-Leuwin	Recherche Archipelago W.A.	Labillardière
Chorizema ilicifolia Labill.	terra van-Leuwin	correct location	Labillardière

A summary of the conclusions of this paper and the previous discussion of *'terra van-Leuwin'* specimens (Nelson, in press) is found in table 3. The information presented is in some cases already known and published but this happened mostly over a hundred years ago through the work of Hooker (1860) and Bentham (1863). The conclusions have little overall taxonomic significance as *locus classicus* (collecting area of a type specimen) is of little consequence in nomenclatural debates Most taxonomists regard specimens without location data attached as of little use unless they are annotated type specimens.

The conclusions do throw some light on the early history of Australian botanical investigations. Labillardière's collections suffered unusual fates, being passed from hand to hand for several years, but they would appear to have suffered little from that experience . Keeping in mind the lapse of four years between the date of collection and the return to France of the specimens from Banks, it is obvious that Labillardière was uncertain about the origin of certain specimens. It is also apparent that Labillardière had access to collections from other workers, despite statements to the contrary (Stafleu 1966). Labillardière must have been in an excellent position, as a regular member of the French Academy of Science and as friend to Desfontaines, who was Curator of the herbarium of *Muséum nationale d'Histoire Naturelle*, to use specimens obtained by Leschenault on Baudin's voyage. Some of this material arrived back in France in 1802 and the Western Australian material reached Paris in 1803, in time for inclusion in *'Novae Hollandiae Plantarum Specimen'* which was published between 1804 and 1807.

While *Novae Hollandiae Plantarum Specimen* contains a large number of descriptions, few of his first set of specimens have been critically examined by later specialists (Stafleu 1966) and no list of his Australian collection, in its entirety, exists. Labillardière had a herbarium of over 4,000 specimens (Chevalier 1953) but in all he only published descriptions of about 400 species; 265 of which were Australian. There are other Australian specimens in his collections, some of which could be the first specimens of the taxa to have been obtained that have never been catalogued; one such species is *Euphrasia kingii* Curtis from Tasmania that Labillardière collected but never listed as he referred it to a New Zealand taxon (Barker pers. comm.)

Also, while several specimens have been noted that were, or could have been collected by Leschenault, it is possible that other specimens from that collector were used in the preparation of Labillardière's descriptions. If Labillardière made extensive use of specimens derived from Leschenault or other botanists, this extraneous material may have been undetected in this study, as the distribution patterns of those species may not

have been inconsistent with the labels used, and Labillardière's known collecting localities. In these cases the type specimens would have been collected, by these other botanists, in places that Labillardière did not visit. Of Labillardière's *'terra van-Leuwin'* specimens listed in the flora (1804) six could only have been collected at Baie Le Grand according to present data. The remainder occur in other areas not visited by Labillardière but visited by Leschenault, Brown or Menzies.

While no records were noted in the work on these papers, it is possible that Labillardière exchanged material with English botanists receiving in return material from collections of Menzies and Brown; Labillardière forwarded specimens to Banks after 1796, and duplicates of Labillardière's specimens are found in collections including those of Lambert (Lasegue 1845).

CONCLUSIONS

As was shown with respect to Labillardière's *'terra van-Leuwin'* species, errors in location of collection occur in species labelled *'capite van-Dieman'*. In most cases the specimens are of Western Australian origin but one specimen apparently was collected in New Caledonia. While there is little nomenclatural significance in these inaccuracies, the establishment of the correct location of Labillardière's collections is important in taxonomic, biogeographical and historical contexts as several of the species described are endemic to restricted areas in Australia. It is unacceptable to continue to regard Labillardière's locations as correct especially in the cases discussed.

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OBSERVATIONS ON SOME TASMANIAN FISHES: PART XX

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(with four text-figures)

ABSTRACT

Three species, *Atypichthys strigatus* (Günther), *Kathetostoma giganteum* Haast, *Navodon multiradiata* (Günther), are reported for the first time from Tasmania. The inclusion in the local list of *Vincentia novaehollandiae* (Valenciennes), on which doubt had been cast by recognition of the validity of *V. lemprieri* (Johnston), is confirmed.

General observations are made on the following species: *Squatina australis* Regan, *Alabes dorsalis* (Richardson), *Alabes rufus* (Macleay), *Anguilla reinhardtii* Steindachner, *Scorpis lineolatus* Kner, *Kathetostoma laeve* (Bloch & Schneider), *Gnathanacanthus goetzeii* Bleeker. A key to the Tasmanian species of Alabetidae is supplied.

INTRODUCTION

This paper follows the general plan of others in the series. Linear measurements are given throughout in millimetres, the name of the unit commonly being omitted. The symbols *Ls, Lt, TLs, Tlt* denote standard length, total length, thousandths of standard length, thousandths of total length, respectively. Standard deviation is calculated with *n* degrees of freedom; derived statistics being computed from the value thus obtained. Registration numbers are those of the Queen Victoria Museum, Launceston. Certain other conventions are noted in earlier contributions.

Family SQUATINIDAE

The family Squatinidae [Rhinidae of early authors — e.g. Günther (1880), Macleay (1881), Johnston (1883,1891), Boulenger (1910)], with a global temperate and tropical distribution, comprises probably fewer than a dozen species, commonly referred to a single genus, *Squatina* Duméril, 1806. Two species have been described from Australia: *S. australis* Regan, 1906 [Check-list distribution New South Wales, Victoria, Tasmania, South Australia; Western Australia added by Whitley (1948)], *S. tergocellata* McCulloch, 1914 [Check-list distribution Great Australian Bight, New South Wales; Western Australia added by Whitley (1948), South Australia by Scott (1962)]. The specific distinctness of McCulloch's species has been questioned, e.g., by Lineaweaver & Backus (1970). [Presumably having in mind the angel shark's well-known habit of lying at times partly buried in mud or sand, these authors derive McCulloch's second binomen (of which he did not note the origin) from *tergus*, bask, and *celo*, hidden: the writer would rather guess a formation from *tergum*, back, and *ocellatus* (*-a*, *- um*), marked with eyelike spots; in allusion to the conspicuous color pattern of the dorsal surface.] Conventionally, the two Australian species should be distinguishable at sight by the color pattern: however, a Tasmanian example of *S. australis* here noted exhibits an interesting approach in this feature to *S. tergocellata*, and, judged solely by it, might rather be referred to that species.

Genus *SQUATINA*

Squatina Duméril, 1806, *Zool. Analyst.*, 102 and 342. Haplotype, *Squalus squatina* Linné, 1758.

Squatina australis Regan, 1906

(fig. 1)

Squatina australis Regan, 1906, *Ann. Mag. Nat. Hist.*, (7), xviii, 438. Type locality, Port Jackson.

Material. A female, *Lt* 307 caught at Sidmouth, Tamar River, on 5 October, 1972 by E. Bennett; Q.V.M. Reg. No. 1972/5/578 (donor, E.W. Gatenby). Some dimensions of a female, *Lt* 1178, netted at a depth of 4-5 m by W. French at Boobyalla Bay in 1940 are also recorded: this specimen is not now available.

Dimensions. Dimensions here given, all expressed as millesimals of total length *(TLt)*, are set out in accordance with the biometric scheme of Whitley (1943), with some additional entries: the value for the 1940 example, where available, is shown in parentheses. Head (H1-H18): H1 169 (136), H2 195 [to anterior border of last gill slit; to tip, 215] (165), H3 42 (44), H4 166 (144), H5 192 (168), H6 423 (394), H7 23 (14), H8 15, H9 76 (59), H10 13, H11 10, H12 68 (62), H13 3 [to anterior border of upper lip; to middle of mouth cleft, 13], H14 134 (130), H15 46, H16 26, H17 80, H18 49. Additional head measurements: length to angle of mouth 95, interspiracular distance 95; length of nostril 0 (slit invading exterior profile), interval between ends of 5th pair of gill slits 81 (84). Body (B1-B9): B1 858 (854), B2 497 (500), B3 653 (664), B4 42, B5 94 (100), B6 23, B7 46 [B8, B9, claspers, not applicable]. Additional body measurements: depth at vent 69, width (body) at vent 147, length of caudal keel 68. Fins (F1-F22:F1 81 (86), F2 41 (39), F3 26 (31) ['last ray'; here, regularly, posterior border], F4 60 (58), F5 75 (79), F6 37 (38), F7 24 (28), F8 52 (55) [F9-F12 not applicable, no anal; F13, sketch, omitted], F14 261 (278) [usual measurement from insertion; measured from tip of cephalic hook, 326], F15 134, F16 233 (266), F17 101 (119), F18 121, Fig 104 (78), [F20 not applicable; no anal], F21 109 (106), F22 179 (128). Additional fin measurements: distal border of pectoral 208 (278), 130 (157) [exceptionally, two distal borders, the anterior the larger], distal border of ventral 173 (170), distal border of first dorsal 46 (53), distal border of second dorsal 42 (46), distal border of caudal 117, posterior border of pectoral 140 (138), posterior border of ventral 104 (78). The length of the forwardly curving anterior border of the exceptionally four-bordered pectoral is, direct 75 (72), between parallels, 72 (68): this border and the anterior portion of the first of the two distal borders constitute a moderately curved hook apparently normally carried beneath the head. Some further dimensions as *TLt* of special interest in a squatinid: interpectoral interval, anterior insertion 147 (144), posterior insertion 202; spread of pectorals, at tip of hooks 215 (183), at distal angles (maximum) 521 (579), at posterior angles 319; spread of ventrals, maximum 326 (357), at posterior angles 130; head, maximum width 261 (225), maximum depth 85; body, maximum depth 107.

Good agreement obtains between most of the dozen dimensions recorded by McCoy (1879) for his Victorian specimen, a female 3 feet 8½ inches (1124mm) long, and those of our examples. With all values expressed as *TLt* we find (Tasmanian material in parentheses, smaller individual first): width across pectorals 539 (521,579), across ventrals 337 (326, 357); length to first dorsal 652 (653, 664); base ('length'), 'height' [apparently direct distance from base to tip] of first dorsal 34 (41,39), 79 (75,69); base, height of second dorsal 39 (37,38), 67 (73,63); interdorsal 67 (60,58); width of mouth 93 (134,110); eye 11 (23,14); eye to spiracle 17 (13,—).

Coloration. The following noqes relate to the small Sidmouth specimen, no observations on the other individual having been recorded.

Ground color of dorsal surface virtually uniform, somewhat greenish dark brown, except on dorsals and caudal where it is somewhat lighter, noticeably more greenish; ground colour of ventral surface of head, trunk, paired fins faintly greyish off-white, of tail dead white; line of demarcation in general sharp, along side of tail the line of brown more or less crenulate. On dorsal surface exposed portions of paired fins and distal margin of second dorsal narrowly margined with white; a number of round white spots

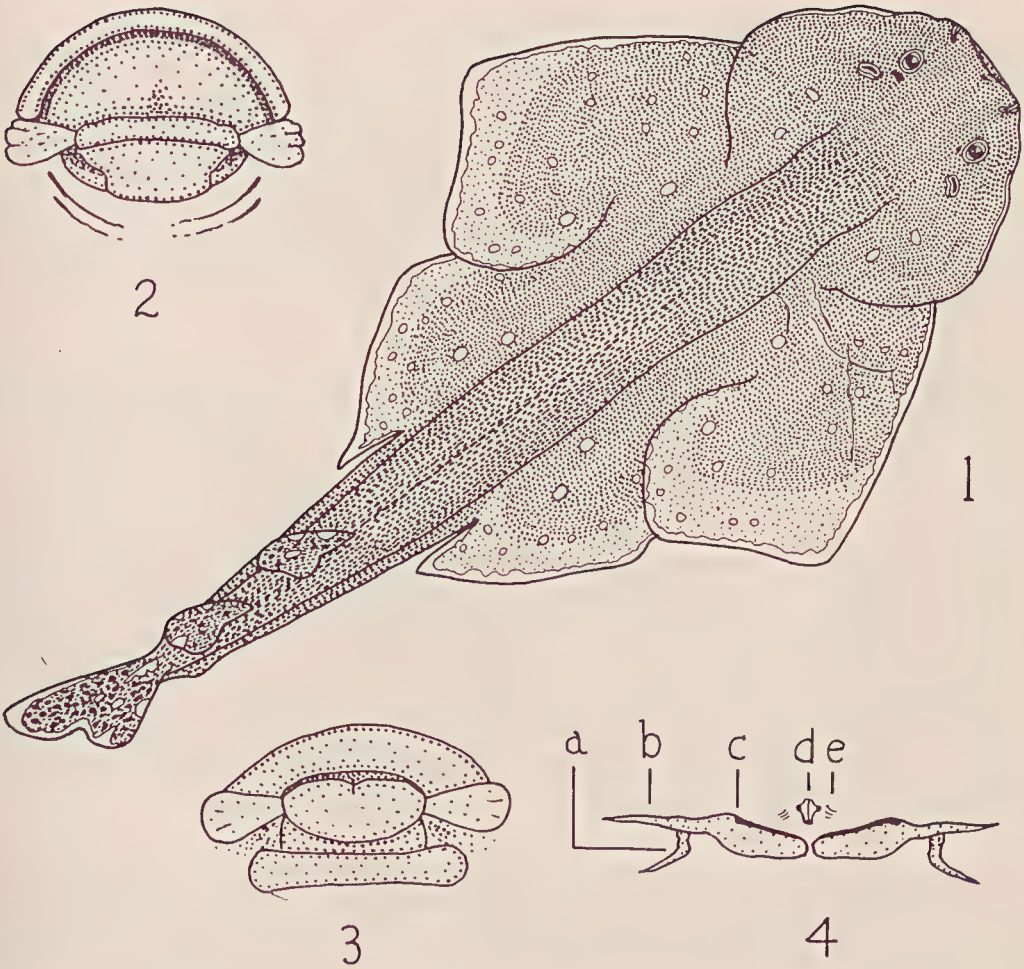

FIG. 1. - *Squatina australis* Regan, 1906. A female, 307 mm in total length, from Sidmouth, Tamar River, Dorset (E. Bennett), Queen Victoria Museum Reg. No. 1972/5/578, with atypical color pattern, showing some resemblance to that of *S. tergocellata* McCulloch, 1914: x ½.

FIG. 2. - *Alabes dorsalis* (Richardson, 1845). External features of branchial region in a specimen, 91.1 mm in total length, from southern Tasmania (B.C. Mollison) x ca 8.

FIG. 3. - *Alabes rufus* (Macleay, 1881). External features of branchial region in a specimen, 72 mm in total length, from southern Tasmania (B.C. Mollison): x ca 10.

FIG. 4. - *Alabes rufus* (Macleay, 1881). Pectoral girdle of a cleared and alizarin-stained specimen from Samphire Island, Bass Strait (A.P. Andrews): x ca. 7. Provisional interpretation of skeletal elements: a, dorsal fork of posttemporal; b, ventral fork of posttemporal; c, cleithrum (the deeply staining sliver, shown black, may represent a supracleithrum); d, coracoid (the deeply staining regions, shown black, may represent additional elements: at end of transverse arm of cross possibly a scapula; at base possibly a mesocoracoid.)

(fig. 1), regularly disposed, nearly always paired, about 2,2,15,8 pairs on head, trunk, pectoral, ventral, respectively; diameter of largest about one-third eye diameter; several unpaired spots (fellow not developed?), but no secondary dispersed white spots such as those seen in the photograph of a specimen of *S. australis* given by Waite (1921 fig. 26) and reproduced in Munro (1956), Scott (1962); no obvious greyish or greenish dots on head or body, but dorsals with a few and caudal with many small darkish, mainly ovoid spots. On ventral surface four or five irregularly disposed dark smudges in anterior one-third of head; indeterminate dark, somewhat bluish transverse discolorations across throat; a small dark spot on each pectoral, near margin, shortly behind anterior angle; some faint duskiness along posterior distal border of pectoral; two or three dark smudges near anterior half of ventral border, posterior half of this border and most of distal border narrowly edged with white; both dorsals and caudal with white spots and splashes, some of these visually interrupting fin contour.

Comparison with *S. tergocellata*. In his description of the holotype of *S. tergocellata*, a female 430 mm long from snout to 'middle of the caudal', McCulloch noted it as differing from *S. australis* as follows: (a) dorsal denticles tricarinate; (b) greater part of [upper surface of] pectorals and ventrals naked; (c) tubercles on snout much larger, differently arranged; (d) interspiracular distance less than interocular; (e) color markings 'altogether different'. In the Sidmouth shark (a) the denticles are unridged, each bearing a single recumbent subcylindrical spinule, much as, but in some cases more acutely pointed than, that figured by McCoy (1879, pl. 34 fig. 1*i*); (b) about the posterior one-fifth of the upper surface of the pectoral, and a marginal strip, about half as wide as least width of fin, along distal border of the ventral are devoid of denticles; (c) tubercles on snout smaller, fewer than those figured by McCulloch, three behind left eye, one behind right, none bordering inner orbital rim; (d) interspiracular exceeding (1.24) interocular; (e) color pattern of dorsal surface quite different from that commonly attributed to *S. australis* (see above, and fig. 1), exhibiting, especially in the presence of paired spots, what might be regarded as an approach to the typical pattern of *S. tergocellata*. It is of interest to observe that Whitley (1940, 157) has mooted the possibility of there being local subspecies of *S. tergocellata*, noting a specimen trawled near Kiama, New South Wales, as 'differing in colour markings from the Bight type' (McCulloch's *Endeavour* specimen came from the Great Australian Bight, Long. 127°-128° E.)

A comparison between, on the one hand, McCulloch's figure of *S. tergocellata*, and on the other hand, the Sidmouth specimen and the figures of *S. australis* in McCoy (1879 pl. 34 fig. 1) and Waite (1921, fig. 36) reveals some differences in general form (data for *S. australis* in parentheses): pectoral with anterior distal border barely (fairly) convex, posterior distal angle rounded (bluntly pointed), posterior distal border slightly sinuous (fairly evenly concave) and equal to or less than (greater than) posterior border: however, the distal border of the ventral, nearly straight in McCulloch's figure and in our specimen, is concave in McCoy's figure, sinuous in Waite's.

Family ALABETIDAE

The above version of the family name is that used by McCulloch in the Check-list (1929); extralimitally, by, among others, Berg (1940), Schultz & Stern (1948), Greenwood *et al.* (1966). Alabidae, the form used by Jordan (1923), is adopted by Munro in the Handbook (1957a) and by Scott (1962) in his South Australian catalogue.

The family, which is essentially an Australian one, contains three satisfactorily recognized species of the genus *Alabes* Cloquet, 1816: (a) *A. dorsalis* (Richardson, 1845), (b) *A. rufus* (Macleay, 1881), (c) *A. parvulus* McCulloch, 1909; of which the first two occur in Tasmania. A fourth species, *A. cuvieri* Vaillant, 1805 ('Australia', India) is included in the Check-list and is retained in Whitley's name-list (1964), but is dropped from the Handbook.

Key to Alabetidae Recorded from Tasmania

A1. Dorsal commencing about above vent (if in advance of vent, nearer to it than to snout tip). Anal commencing well behind vent (by about a head length). Greenish or almost colorless [on preservation turning reddish (alcohol) or yellowish (formalin)]; with, rarely without, 1-9 large spots on side [purplish (alcohol), red (formalin)]; no median stripe. *A. rufus*.

A2. Dorsal commencing shortly behind head (nearer to snout tip than to vent). Anal commencing close behind vent (by about an eye diameter). Brown or blackish brown; no large spots on side; a median dorsal stripe (not always observable after preservation) [in formalin light brown, with or without a purplish cast; fins more or less yellowish, becoming in part whitish distally]. *A. dorsalis*

Genus *ALABES* Cloquet, 1816

Alabes Cloquet, 1816, *Dict. Sci. Mat.*, 1, suppl. 1816, 99, *Ex* Cuvier MS. Logotype, *A. cuvieri* Vaillant.
Alabes dorsalis (Richardson, 1845).

Cheilobranchus dorsalis Richardson, 1845, *Zool. Voy. Erebus and Terror, Fish*, 50, pl. xxx, figs 1-5. Type locality, North West Australia.

Distribution. The Check-list gives north-western Australia, Tasmania, South Australia, only the first of which was noted by Macleay (1881b, 266): the Handbook queries South Australia, and Scott (1962) does not include the species in his catalogue for that state. It appears in all published Tasmanian lists, and, *fide* Johnston (1883, 133), in Martin Allport's MS catalogue; Johnston noting 'Tasmanian specimens 90 mil. long (Gunn and Günther)'. In Lord (1923) and in Lord and Scott (1924) it is referred to *Cheilobranchus* Richardson, 1845; in both Johnston's lists and in Macleay to *Chilobranchus* Günther, 1870, an emendation of Richardson's name; in Lord (1927) to *Alabes*. The apparent discontinuous distribution of north-western Australia and Tasmania appears curious. Also, *C. aptenodytum* Richardson, 1845 from South Victoria Land (Penguin Island, lat. 72°S.) was treated by Gunther as a synonym of *C. dorsalis*. As Waite (1906, 196) remarked, 'If the species be the same, the extremes of latitude, furnish a remarkable instance of geographical range'.

Tasmanian material. Though the writer has collected hundreds of specimens of *A. rufus* and has kept a constant lookout for *A. dorsalis*, he has not himself encountered an example of the latter species. It was therefore a matter of considerable interest to find two specimens in a small collection of fish made by Mr B.C. Mollison in southern Tasmania (precise locality not recorded).

Length. With *Lt* 88.7, 91.1, *Ls* 87.7, 90.0 the fish reach the size apparently regarded by Johnston as noteworthy, and equal the '3½ inches' of the Handbook.

Dimensions as *TLt*. Length to origin of dorsal 135, *ca* 140 (precise origin difficult of determination); of anal 388, 390. Length to vent 384, 386. Head 114, 121; snout 23, 23; eye (heavily pigmented portion, mostly exposed through membrane) 18,18, (total), 23, 23; interorbital 43, 40; distance between eyeballs, visible through dorsum 23,24; distance between anterior nostrils 24, 26. Depth (in parentheses width) at: front of eyes 53 (56), 49 (54); back of eyes 67 (68), 64 (75); gill opening 101 (57), 76 (65); vent 78 (68), 109 (54): maximum, head 101 (77), 77 (77), body 109 (68), 115 (63). Maximum height of dorsal 32,31; of anal 23,23.

Some proportions. Head in *Lt* 8.8, 8.3; in trunk 2.4, 2.3. Length to vent in postvent length 1.6, 1.6. Height in *Lt* 9.2, 8.7. Eye (total) in head 5.1, 5.2; in snout 1.0, 1.0; in interorbital 1.9, 1.7. Length to dorsal origin 7.4, *ca* 7.0; to anal origin 2.6, 2.6 in *Lt*.

Other features Myomeres *ca* 21+55. Mouth small, cleft nearly horizontal, reaching just to level of (full) eye; upper jaw projecting slightly; lips tumid, subequal in width through-

out most of their length and subequal to each other; tip of maxilla distant from pigmented part of eye by about diameter of latter. Teeth in the jaws in a single series of 10-12 on each side, closely set, forming a continuous ridge throughout most of their height, the briefly projecting tips bluntly pointed; a short almost straight transverse line of several contiguous teeth on vomer. Anterior nostril close to (full) eye at about 10 o'clock (left side viewed); a wide, very short tube, the whole of its outer border continuing as an erect subrectangular flap, whose height equals, or slightly exceeds, basal diameter of tube; internarial subequal to distance of level of insertion of nares behind anterior border of lip. Posterior nostril situated behind, and a trifle mesiad of, anterior, from which it is distant by about half its distance from its fellow; a low simple tube, its elliptical opening transverse, a little oblique, the external end slightly in advance of the internal.

Dorsal originating, rather obscurely, shortly behind head (by less than length of postorbital head); anteriorly a low fleshy ridge; posteriorly, remaining fleshy proximally, but developing a progressively wider distal strip, accounting near tip of tail for about half height of fin, here being thinner, more or less translucent; the external margin almost even throughout, but, as the fish lies, with most of the hinder half wavy in the vertical plane. Anal originating almost immediately behind vent (by an eye diameter or less); similar to dorsal, but distinctly lower; margin somewhat crenulate, and, as the fish lies, most of fin wavy in the vertical plane, moderately in (a), slightly in (b). Tip of tail with a continuous, rounded fin line, appearing superficially to be constituted by confluence of dorsal and anal, but seen under a lens to include a small rudimentary caudal with 6-8 short thickish simple rays, not, or barely, extending to border of membrane, their length about 1 mm, subequal to combined anteroposterior extension of last two vertebrae.

Branchial region. The account of the single transverse ventral gill opening and the immediately adjacent region given by Richardson has been somewhat critically discussed by Waite (1906). Some observations on the relevant structures and their interpretation in the present species and in *A. rufus* are included below in notes on the latter.

Alabes rufus (Macleay, 1881)

Chilobranchus rufus Macleay, 1881, *Proc. Linn. Soc. N.S.W.*, vi, 2, 266. Type localities, Port Jackson and Tasmania.

Dimensions as *TLt*. A schedule of dimensions as millesimals of total length similar to that given above for *A. dorsalis* is here provided; based on 5 examples, *Lt* 60,61, 63, 72, 80, from southern Tasmania (B.C. Mollison). Length to origin of dorsal 326-375, $\bar{x}$ 346.4 ± 8.81; of anal 492-533, $\bar{x}$ 512.2 ± 7.09. Length to vent 361-400, $\bar{x}$ 383.0 ± 6.43. Head 108-124, $\bar{x}$ 116.2 ± 2.42; snout 18-31, $\bar{x}$ 23.4 ± 1.97; eye (heavily pigmented portion, mostly exposed through membrane) 17-20, $\bar{x}$ 19.0 ± 1.10, (total) 28-33, $\bar{x}$ 30.8 ± 1.09; interorbital 34-43, $\bar{x}$ 38.2 ± 1.64; distance between eyeballs, visible through dorsum 24-30, $\bar{x}$ 26.2 0.91; distance between anterior nostrils 31-34, $\bar{x}$ 31.8 ± 0.95. Depth (in parentheses width) at: front of eyes 42-50, $\bar{x}$ 45.6 ± 1.19 (41-48, $\bar{x}$ 43.4 ± 1.11); back of eyes 62-73, $\bar{x}$ 67.0 ± 1.94 (64-73, $\bar{x}$ 67.0 ± 1.41); gill opening 68-95, $\bar{x}$ 78.2 4.51 (66-73, $\bar{x}$ 69.6 ± 1.19); vent 95-113, $\bar{x}$ 101.6 ± 3.01 (55-67, $\bar{x}$ 63.4 ± 1.40): maximum, head 70-84, $\bar{x}$ 78.6 ± 3.01 (68-84, $\bar{x}$ 75.2 ± 2.29), body 100-111, $\bar{x}$ 106.6 ± 2.24 (67-75, $\bar{x}$ 71.4 ± 1.20). Maximum height of dorsal 26-38, $\bar{x}$ 32.4 ± 1.71, of anal 19-26, $\bar{x}$ 22.2 ± 1.82. These *TLt* values exhibit no marked variation from those of *A. dorsalis* except, of course, in the critical length to dorsal (346.4, *cf. ca* 138) and length to anal (512.2, *cf.* 389).

Some proportions. Proportions recorded above for *A. dorsalis* are here noted for the present species: they include all those reported by Waite (1906) for his Victorian material (his values in parentheses). Head in *Lt* 8.4-9.2, $\bar{x}$ 8.80 ± 0.13 ('eight'); in trunk 2.0-2.6 $\bar{x}$ 2.25 ± 0.092 (21.3. Length to vent in postvent length 1.5-1.8, $\bar{x}$ 1.61 ± 0.040 (1.5). Height in *Lt* 9.0-10.0, $\bar{x}$ 9.40 ± 1.58 (8.6). Eye (total) in head 3.3-4.5, $\bar{x}$ 3.18 ± 0.18 (3.2); in snout 0.6-1.1, $\bar{x}$ 0.79 ± 0.11; in interorbital 1.2-1.3, $\bar{x}$ 1.24 ±

0.069. Length to dorsal origin 2.7-3.1, $\bar{x}$ 2.89 ± 0.69; to anal origin 1.9-2.0, $\bar{x}$ 1.96 ± 0.024. For the three ratios involving the eye the coefficients of variation are too great (say, conventionally, 10) to have much taxonomic significance, being 13.0, 30.6, 12.5, respectively: coefficients for the remaining ratios are of a satisfactory magnitude, their values being, in order of the non-eye entries above, 3.3, 8.9, 5.5, 4.8, 5.4, 2.8.

Branchial region. Describing the gill opening of *Cheilobranchus rufus* Richardson (1845, 50) wrote, 'A transverse lip which rises above the surrounding integument, and has its outer ends free, forms the posterior edge of the orifice, and appears to be capable of closing it very completely when the inflected edge of the membrane is pressed against it'. Commenting on this passage, Waite (1906,196), with examples of *A. rufus* only before him, remarked 'This "lip" is present also in *C. rufus;* it is not a median process as might be inferred, but really a pair of organs which to my eye are nothing but rudimentary pectoral fins. They lie rather low down on the body, some distance apart, close behind, but quite free from the gill membrane, and it is very doubtful if they have any function in connection therewith, as supposed by Richardson.'

It will be noted that Waite appears to assume the branchial region is the same in the two species. This is not quite the case, at any rate in our material. However, the difference lies, not in the existence of different structures, but rather in the degree of development of those present, and an examination of these specimens goes far towards providing a basis for a plausible reconciliation of the two accounts. In *A. dorsalis* (fig. 2) the paired structures regarded by Waite (in all probability, correctly; in one individual each appears to have two or three fin rays) as pectoral fins (vestigial, perhaps, rather than rudimentary) are found at the ends of a rather narrow transverse process, with which they are wholly continuous: this bar, which lies immediately in advance of a pillow-like eminence, about half as extensive transversely as the whole apparatus, could well be interpreted as a median 'transverse lip' forming 'the posterior edge of the orifice' and as conceivably being 'capable of closing it very completely'. However, in *A. rufus* (fig. 3) the transverse process, as such, is either undeveloped, or, in some individuals, somewhat doubtfully recognizable as a very narrow fold, its place being usurped by an enlarged median pillow, immediately flanked on either side by the small fans presumed to be degenerate pectorals: as the pillow can reasonably be regarded as being simply a local elevation calling for no express mention, this situation would appear to be compatible with that recognized by Waite.

Mr A.P. Andrews, Curator of Vertebrates, Tasmanian Museum, Hobart, has been good enough to prepare at the writer's request a specimen of *A. rufus*, cleared in potassium hydroxide and stained with alizarin. The pectoral girdle is found to exhibit some interesting evidence of degeneration (fig. 4); the situation, as here provisionally interpreted on the basis of this specimen, being as follows. The cleithrum and supracleithrum together constitute a subelliptical plate, quite the largest element of the system. The posttemporal presents a rather short proximal portion, beyond which it is strongly forked; the pennonlike dorsal prong projecting upwards, outwards, and somewhat backwards, its tip remote from the skull, not possessing, as far as can be seen, any ligamentous connexion with the epiotic region; the ventral prong being angled, with a short forwardly and slightly inwardly directed proximal segment, continued upwards and backwards in a segment about thrice as long, making connexion (ligamentous?) with the skull at, or near, the opisthotic. The two cleithral complexes come into close approximation in the median line, what appear to be the two coracoids (with, perhaps, associated scapulas) being pushed out from between them, closely apposed to form a cruciform unit, lying wholly clear of the cleithra within the bay bounded by the latter bones' posterior borders, from which borders they are distant, at their nearest approach, by rather more than half their own length. A small area of intensified color in the stain at each of the outer ends of the cross may represent a much reduced scapula. Two similar, but smaller, patches detectable at the base (anterior end) of the cross may relate to some other minute, wholly fused element (mesocoracoid?). External to each presumed scapula, and lying free from it at a

distance of about half their own length or more, are three actinosts, the external one the largest: these lie in a plane a trifle dorsad of that of the scapula, the plane of which is, in turn, somewhat dorsad of that of the cleithra at their internal ends. There are three gill arches, almost equally developed.

Markings. The number of spots along each side is conventionally given as 6-7 (e.g., Macleay, 1881b, Waite, 1906, Scott, 1962); 'with or without 6-7' (Munro, 1957a): we find 0-9. As Waite pointed out, the pattern may not be the same on the two sides. A sample of 37 fish collected between Green's Beach and Kelso, on 8 January 1967 by Mr R.H. Green (Q.V.M. Reg. No. 1972/5/26) gives the following frequency distribution: left side 0 (5 cases), 1 (1), 2 (3), 3 (3), 4 (10), 5 (7), 6 (2), 7 (5), 8 (0), 9 (1), total 147; right side 0 (5), 1 (1), 2 (1), 3 (8), 4 (6), 5 (8), 6 (4), 7 (2), 8 (1), 9 (1), total 146; mean per side 4.0 ± 4.1, or, among marked individuals, 4.6 ± 4.1. Different counts (greatest difference 2 spots) occur in 16 fish. It will be seen that while the totals of the two sides are virtually the same, the modes differ (possibly by mere sampling variation), being 4 on the left side and 3,5 (equal) on the right. Waite's statement that the spots do not extend beyond the origin of the anal is generally, but not invariably, true, the hindmost spot in some individuals being located more than a head length further caudal. Exceptionally, one or two spots (not necessarily collinear with the others) occur on the head.

Vernacular name. The 'Red-banded Shore Eel' of the Tasmanian lists of Johnston, Lord, Lord & Scott, and the 'Red-banded Pigmy Eel' of Munro's Handbook seem decidedly inappropriate, the characteristic markings being well-separated rounded spots, without any suggestion of a band or bands. Shore Eel is used for this species by Scott and for *A. dorsalis* by Munro. Perhaps a convenient name would be Red-spotted Shore Eel.

Family ANGUILLIDAE

The two species reported from Tasmania — *Anguilla australis* Richardson, 1841, (Handbook (Munro, 1957b, 53), *A. australis occidentalis* Schmidt, 1928), *A. reinhardtii* Steindachner, 1867 (Handbook, *reinhardti)* — have been keyed in Part VI (1953, 142) [numbered V]. The other species of *Anguilla* reliably recorded from Australia, *A. bicolor* McClelland, 1845, *A. obscura* Gunther, 1871, do not reach south of Queensland and north-western Western Australia.

Genus *ANGUILLA* Shaw, 1803

Anguilla Shaw, 1803, *Gen, Zool. (Pisces)*, IV, 1, 15. Logotype, *Muraena anguilla* Linné.

Anguilla reinhardtii Steindachner, 1867.

Anguilla reinhardtii Steindachner, 1867, *Sitzb. Akad. Wiss. Wien*, lv, 1, 15, figs a-b. Type locality, Fitzroy River, Rockhampton.

Tasmanian status. The Australian long-finned eel does not appear in either of Johnston's lists (1883, 1891), but is treated as Tasmanian by Lord (1923, 1927), by Lord & Scott (1924) and by McCulloch (1929) in the Check list ['Rivers of Eastern Australia (Queensland to Tasmania) ...']. However, in his notable paper on the freshwater eels of Australia Schmidt (1928) expressly states of *A. reinhardtii* 'in Tasmania it has not yet been observed', and the Handbook (Munro 1957b, 53), which is to be regarded as presenting the current conventional view, restricts the [Australian] distribution to Queensland, New South Wales, Victoria.

In a paper (1934), that, by virtue of the appearance of sequent contributions, became in effect Part I of the present series, though not so numbered, notice was taken of three long-finned eels (now apparently lost sight of) exhibited in the Queen Victoria Museum, Launceston because of their size, *Lt* 1531, 1525, 1635 mm. The Schmidt index [$s=\frac{a-d}{t} \times 100$, where a = length to vent, d = length to dorsal origin, t = total length]

reported by Schmidt for *A. australis* ranges from —1.5 to +4.0, $\bar{x}$ 1.27, for *A. reinhardtii* from 7.8 to 13.2, $\bar{x}$ 10.7. Values for the eels mentioned above were 10.8, 11.2, 11.4. The death of Professor Schmidt in 1933 prevented the completion of an arrangement that was being made for him to examine these specimens. In Part II (1935, 65) an example, *Lt* 1658, *S* 13.1, caught near Launceston on 16 April 1934, was reported; while Part VI (1953,142) [numbered V] noted an example, *Lt* 1671, *S* 10.7, stabbed to death with a pocket knife in the North Esk at Launceston on 13 August 1937. The latter contribution provides a series of dimensions (table 1) of five large Tasmanian specimens of this species. A large example, not previously recorded, was taken by Mr Blake in the Lake River, a tributary of the Macquarie, in December 1940. Some dimensions (mm); total length 1338; length to dorsal, anal, vent 457, 600, 574; length of head, snout, eye, pectoral 184, 58, 12, 81; interorbital 46; girth at pectoral base, at vent, maximum 331, 391, 416. Weight 10.8 kg. $\bar{S}$ = 9.1. Of a considerable number of Tasmanian eels since seen by the writer all, up to the present time, have been *A. australis*.

Flinders Island records. Two large eels from south-east Flinders Island collected on 17 November 1972 (*Lt* 1333), Q.V.M. Reg. No. 1972/5/747, and 12 December 1972 (*Lt* 975), Q.V.M. Reg. No. 1973/5/74, by Mr. G.D. Smith are determined as *A. reinhardtii*.

Proportions as *TLt*. *Ls* 971, 974 (earlier specimens first). Length to: pectoral origin 135, 154; dorsal origin 336, 354; vent (middle) 431, 466; anal origin 442, 485. Head 138, 154; snout 29, 31; eye 9.8, 9.8; interorbital 37, 32; mouth cleft 43, 43; anterior internarial 15, 17, posterior internarial 31, 25; length of pectoral 60, 52; depth at vent 91, 76; maximum depth 91, 77; girth at dorsal origin 302, 246. *S* 10.6, 11.2.

Other features. Maxilla to behind eye by 0.6, 1.0 eye. Pectoral 18, 18, short, broad, rounded. Lower jaw exceeds upper by 0.5, 0.2 eye. Larger specimen blackish, almost immaculate; small lighter, profusely spotted, a feature distinguishing this species from *A. australis* , and also from the New Zealand long-finned eel, *A. diffenbachii* Gray, 1842 (in Schmidt's papers, *A. aucklandii* Richardson, 1848), regarding which Schmidt observed in 1932 in a letter to the writer 'There seems to be a reason to keep a sharp look out for this species in Tasmania'.

Family APOGONIDAE

The five species recorded from Tasmania — *Dinolestes lewini* (Griffith, 1834), *Lovamia fasciata* (Shaw, 1790), *Siphamia cephalotes* (Castelnau, 1875), *Vincentia novaehollandiae* (Valenciennes, 1832), *Vincentia lemprièri* (Johnston, 1883) — have been keyed in Part XII (1964:99). The specification in the key regarding spines of the second dorsal is an error.

Genus *VINCENTIA* Castelnau, 1872

Vincentia Castelnau, 1872, *Proc. Zool. Acclim. Soc. Vict.*, 1, 245. Haplotype, *Vincentia waterhousii* Castelnau.

Vincentia novaehollandiae (Valenciennes, 1832)

Apogon novae-hollandiae Valenciennes, 1832, *Nouv. Ann. Mus. Hist. Nat. Paris*, 1, 55, pl. IV , fig. 2. Type locality, 'Australia' (Quoy & Gaimard): Check-list 'probably = New South Wales'.

Tasmanian status. With Valenciennes' species the Handbook (Munro 1960, 144) synonymizes *V. conspersus* (Klunzinger, 1872), *V. waterhousii* Castelnau, 1872, *V. guntheri* (Castelnau, 1872), *V. lemprieri* (Johnston, 1883) and *V. ramsayi* (Fowler, 1908), the overall range including all Australian States other than Queensland. In Part XII of these Observations (1964, 99, fig. 1) two examples of a *Vincentia* from Akaroa, near St Helens, identified as Johnston's *Apogon lemprièri* were described and figured, being regarded as being separable from *V. novaehollandiae* as characterized in the Handbook by several characters

discussed below: a third example, also from St Helens, was noticed in Part XVII (1970, 44). The validation of *V. lemprièri* (type locality, Dunkley's Point, Sandy Bay, Tasmania) as a species distinct from *V. novaehollandia* (type locality, probably New South Wales) raises the question as to whether the latter is to be regarded as having any standing in the local faunal list.

Tasmanian record. A specimen of *V. novaehollandiae*, *Ls* 22.5, *Lt* 29, has now been identified in the collections of the Queen Victoria Museum, Launceston: Reg. No. 1972/5/448. It was collected on 28 April 1972 by Messrs R. and Y. Graeme at Clarence Point, Tamar River, being found among seaweed.

Meristic characters. D. VII, I, 8. A. II, 9. P. ii, 11/ii, 12. V.I, 5. L.l. 25.

Other features. Head 2.4in *Ls*. Eye 3.1, snout 4.8, interorbital 3.1, pectoral 1.6, pelvic 1.1, maximum depth 1.1, in head.

Dorsals united. Maxilla to posterior border of pupil. Pectoral and pelvic to second anal spine. Most scales on head or body with microscopic reddish brown punctulations, these not aggregating to form microscopic spots. Indications of some dark coloration on part of first dorsal (membrane imperfect), some dorsal rays dark distally; pelvic dusky in distal half; pectoral and anal more or less colorless, immaculate.

Discussion. Of the four features deployed in the couplet of the 1964 key covering *V. novaehollandiae* and *V. lemprièri* perhaps only the first (dorsals united in former, separate in latter) is here significant. Of the others, the second (character of teeth) is probably mainly a question of description; the third (relative length of longest dorsal spine and head) cannot here be employed, the spine being imperfect; while a noticeably greater numerical value (2.0-2.4, *cf.* 1.0-1.1) met with in the 1964 material of the latter species was not found to characterize the 1970 individual, in which the value was close to that of unity as in the present fish.

Family SCORPIDAE

The family Scorpidae (the name is sometimes — e.g. by McCulloch, 1922 — rendered Scorpididae) is recognized by most authors; however, in the provisional classification of living teleosts of Greenwood *et al.* (1966) Scorpidae (Scorpididae) is subsumed, along with Parascorpididae and Girellidae, in Kyphosidae (Cyphosidae).

Only one member of the Scorpidae, *s.s.*, *Scorpis georgiæus* Valenciennes, 1822, is credited to Tasmanian in the Check-list (McCulloch 1929). However, the local list now comprises four species, *S. aequipinnis* Richardson, 1848, having been recorded from near George Town, Dorset in Part II of these observations (1935, 67) and *S. lineolatus* Kner, 1865 from Swimcart Beach, near St Helens, Dorset in Part XVII (1970, 45), while *Atypichthys strigatus* (Günther, 1860) is here reported from George Bay, Cornwall/Dorset.

For a key to the three Tasmanian species of *Scorpis* Valenciennes, 1822 reference may be made to Part XVII. *Atypichthys strigatus* may be distinguished from the keyed species thus:

Dorsal spines IX-X; dorsal rays, anal rays each > 20 (*ca* 23-28); highest dorsal spine lower than highest dorsal ray; color markings dark vertical bars, or dark spots, or none — Tasmanian species of *Scorpis*. Dorsal spines XI-XII; dorsal rays, anal rays each < 20 (*ca* 15-16); highest dorsal spine higher than highest dorsal ray; color markings longitudinal (6-8 brown stripes) — *Atypichthys strigatus*.

Genus *ATYPICHTHYS* Gunther, 1862

Atypichthys Günther, 1862, *Cat. Fish. Brit. Mus.*, 4, 510. *Nom. nov. pro Atypus* Günther, 1860, preocc. in Arachnida. Haplotype *Atypus strigatus* Günther, 1860.

Atypichthys strigatus (Gunther, 1860)

Atypus strigatus Günther, 1860, *Cat. Fish. Brit. Mus.*, 2, 64 and 518. Type localities, Swan River, W. Australia; Holdfast Bay, S. Australia; Raoul Is.; Erromanga, New Hebrides.

Atypichthys mado Whitley, 1931, *Aust. Zool.*, 6, 4, 319. Type locality, Manley, New South Wales.

Tasmanian record. Three examples, 102-110 in standard length, were collected by Mr K.J. Atherton in George Bay, on 14 January 1973 (Q.V.M. Reg. No. 1973/5/29). In the same month the mado was reported by scuba divers also from Stony Head, Dorset, and Clarke Island, Furneaux Group, Bass Strait.

Distribution and status. The Check-list distribution is Queensland, New South Wales, Western Australia, South Australia, New Zealand, Western Pacific. Whitley (1931, 319) observed of Günther's description it 'appears to be a compound one based on specimens, probably not conspecific, from diverse localities'; and designated Raoul Island, Kermadec Group, as the type locality of *A. strigatus*. He then proposed a specimen from Manley, New South Wales as holotype of a new species, *A. mado*, 'the Peronian representative of *A. strigatus*'. In a later publication (1962, 157) the entry for *A. mado* (with Steindachner's figure) gives its distribution as 'Q'ld and N.S.W. with close relatives from W.A. to New Zealand and some south-western Pacific Islands'; and *A. strigatus* appears formally in the New Zealand check-list (Whitley, 1968,61). As a further complication, it is to be noted that though South Australia appears among the type localities of Günther's material, Scott (1962, 223) observes that the record for that State is 'extremely doubtful'. It would thus appear the reported patterns of distribution provide no clear pointer to the identity of the Tasmanian fish, if, indeed, *A. strigatus* and *A. mado* are distinct. Morphologically, the latter is noted as differentiated from the former only by 'the small scales'. Günther's material is reported as having l.l. 70-75, l. tr. 11/26: our values are 70-78, 11-12/24-26 — there thus appears to be no morphological ground for distinguishing the Tasmanian fish from *S. strigatus*.

Length. *Ls* (a) 102.1, (b) 104.5, (c) 110.2. *Lt*, upper lobe, lower lobe of caudal 138.5, 135.0; 134.1, 133.0; 143.1, 140.0.

Meristic characters. D. XI, 16; XI, 16; XII, 16 (first spine minute (1.2mm), wholly detached from rest of fin). A. III, 16; III, 17; III, 17. P. 1,15 (left)/1,15 (right); 2,15/1,15; 2,15/1,16. V.I, 5. C. 10+8; 10+8; 9+9. L.l. 70; 75; 78. L. tr. 11/26; 12/24; 12/25.

Some dimensions as *TLs*. Length to origin, termination of first dorsal (spine-spine) 326, 676; 331, 660; 336 (normal spine), 700: of second dorsal (ray-ray) 734, 911; 717, 863; 757, 883: of anal 593, 917; 573, 883; 623, 871. Pectoral: length to origin, length of fin, length of longest (4th) ray 264, 273, 246; 249, 242, 230; 263, 263, 235. Ventral: length to origin, length of fin, length of longest ray (next to spine) 354, 222, 211; 325, 208, 187; 297, 193, 190. Length to vent, front, back 552, 562; 535, 568; 564, 599. Head 293; 278; 272. Snout 66.6; 67.0; 64.4. Eye 97.9; 94.7; 91.7. Interorbital 101; 98.6; 95.3. Depth at front of eye 157; 163; 150: at back of eye 289; 292; 288: at opercular border 411; 392; 404: at first dorsal origin 470; 440; 454: at middle of vent 470; 440; 386: at caudal peduncle (minimum) 118; 118; 109: maximum depth 495; 459; 481. Dorsal rays: first, longest, last 96.0, 116, 76.4; 90.0, 105, 77.5; 80.8, 101, 72.6. Anal rays: first, longest, last 89.1, 105, 71.5; 95.7, 106, 67.9; 91.6, 92.6, 66.2.

Dorsal spine pattern. For a general discussion of these interesting spine and ray length - number patterns, together with notation conventions, see Part XIX (1974). The minute supernumerary spine of specimen (c) in advance of, and wholly detached from, the rest of the fin is not included in the pattern specified below. $D = D_1 \quad D_2$. $D_1 \quad D_2 = \emptyset$. For each specimen there is given below: first, a tabulation of the members of the subset; secondly, the equation for the regression of L (length of spine, mm) on N or N^1

(serial number of spine counted caudad, or counted cephalad); thirdly, t; fourthly, spine lengths (mm) calculated from the equation (in parentheses measured lengths).

(a) $D_1 = x / x$ = I-VI : $\log L = 0.4686 \log N + 0.9081$: $t = 41.081$:8.1 (8.1), 11.2 (11.0), 13.5 (13.9), 15.5 (15.6), 17.2 (17.1), 18.7 (18.6). $D_2 = x / x$ = VII-XI: $\log L = 0.3652 \log N^1 + 0.9752$: $t = 9.706$: 9.4 (9.5), 12.2 (12.1), 14.1 (13.9), 15.7 (15.9), 17.0 (17.0).

(b) $D_1 = x / x$ = I-V : $\log L = 0.4737 N + 0.9048$: $t = 40.530$: 8.0 (8.0), 11.2 (11.1), 13.5 (13.8), 15.5 (15.5), 17.2 (17.0). $D_2 = x / x$ = VI-XI; but VI imperfect, calculated VII-XI : $\log L = 0.3277 \log N^1 + 0.9589$:$t = 5.833$: 9.1 (9.1), 11.4 (11.1), 13.0 (13.0), 14.3 (14.0), 15.4 (15.5).

(c) $D_1 = x / x$ = I-IV : $\log L = 0.6483 \log N + 0.8534$: $t = 4.241$: 7.1 (7.0), 11.2 (11.0), 14.6 (14.8), 17.6 (18.0). $D_2 = x / x$ V-XI : $\log L = 0.3164 \log N^1 + 0.9638$: $t = 27.695$: 9.2 (9.0), 11.5 (11.8), 13.0 (13.3), 14.3 (14.0), 15.3 (15.3), 16.2 (16.1), 17.0 (17.0).

Note there is not here, as there is in most species so far examined, a unique serial number for the largest member of D, the number of elements of D_1 ranging from 6 to 4, decreasing (?functionally,? adventitiously) with increasing size of specimen. Of the four sets of parameters of the equations for the three specimens, the coefficient of $\log N$ and the independent term of D_1 vary directly, and the coefficient of $\log N^1$ inversely, with length of fish; but the sequence in decreasing magnitude of the independent term of D_2 is (a), (b), (c). None of the three correlations is statistically significant: however, their group existence, especially when considered in conjunction with the occurrence in other fins (see below) of comparable sequences, would seem to indicate the relation is a genuine one.

Anal spine pattern. $A = x / x$ = I, III, II . In the species first investigated the logarithmic lengths of anal spines I, II, III were found to be a linear function of the logarithms of 1, 2, 3, respectively (slope positive). Here the second spine is the longest. However, log lengths of such a series (I, III, II) on logs 1, 2, 3, respectively, are significantly collinear. This relation has been found to hold also in other species with m = II. To supplement N, N^1, already in use, denoting serial number in a set, counting caudad (in unpaired fins; in paired fins 'onwards', by prescribed conventions) cephalad, respectively, N^A is here introduced ('A' from 'arbitrary') to denote a series of positional numbers arranged in a special sequence.

(a) $\text{Log } L = 0.3868 \log N^A + 1.0235$: $t = 23.101$. 10.5 (10.5). 13.8 (14.0). 16.1 (16.0).

(b) $\text{Log } L = 0.3991 \log N^A + 1.0012$: $t = 11.709$. 10.0 (10.1), 13.2 (12.9), 15.4 (15.6)

(c) $\text{Log } L = 0.4055 \log N^A + 0.9991$: $t = 8.174$. 10.0 (10.1), 13.2 (12.8), 15.6 (15.9).

Ventral ray and spine pattern. In the ventral fin of some species examined, in which the longest ray, m, is the 4th (counting outwards towards spine), the pattern found is $vV = v_1 \cup v_2V$; with $v_1 = x / x$ = 1-4 v_2V x / x = 4,5,I (spine) $= m$ — the spine being plotted on log 10, an ad hoc procedure lacking any obvious significance, but in practice commonly yielding a significant best straight line for the three elements. In the present species, in which the longest ray is the 5th, the formulation that best fits the data is $v = x / x$ = 3-5 [descending] $v_2 V = x / x$ = 1, 2, I [ascending] = Ø.

u_1 (a) $\text{Log } L = -0.1645 \log N^1 + 1.3232$: $t = 20.629$: 21.0 (21.0), 18.8 (18.5), 17.6 (17.5).

(b) $\text{Log } L = -0.1776 \log N^1 + 1.3031$: $t = 8.706$: 21.0 (20.0), 17.8 (18.0), 16.5 (16.4).

(c) $\text{Log } L = -0.2054 \log N^1 + 1.3332$: $t = 7.609$: 21.5 (21.4), 18.7 (19.0), 17.2 (17.0).

u_2,V (a) Log L = 0.1625 log N^A +1.0944: t = 14.023: 12.4 (12.4), 13.9 (14.0), 14.7 (14.8).
(b) Log L = 0.1013 log N^A +1.1152: t = 8.170: 13.0 (13.0), 14.0 (14.1), 14.6 (14.5).
(c) Log L = 0.1379 log N^A +1.1107: t = 16.333: 12.9 (12.9), 14.2 (14.2), 15.0 (15.0).

Non-metrical features. Jaws equal anteriorly. Mouth to 0.5 eye (all individuals). Width of maxilla subequal to its direct distance from eye. Preorbital dentate. Preoperculum strongly spinulate. Posterior nostril set obliquely downward and forward, about twice size of anterior, from which it is distant as far as from eye or a little less. Interorbital strongly convex. Pectoral extending 0.9 (all specimens) of distance to vent; ventral to anal origin, midway between vent and anal origin, end of vent. Scaly sheath on dorsal rays and anal rays, not on spines of either fin; compact, extending up at least 4/5 of the lengths of the rays, only the branched tips of these delicately projecting. The extensive development of sheath in the anal here contrasts strongly with the quite narrow basal strip in Steindachner's figure (in which, as far as can be judged from reproductions of the figure in local texts, the dorsal rays also appear to be traceable throughout most of their length, unhidden by any sheath). First anal spine attached by membrane to basal 1/5, 1/4, 1/5 of second, which is attached to basal — (damaged), ½, ½ of third, which is attached from its basal 2/3, 19/20, 5/6 to first ray.

Coloration. Ground color yellowish or whitish, becoming lighter and somewhat more silvery on lower part of lateral surface; ventral surface approximating white. Characteristically with 7 strongly-marked well-delimited longitudinal stripes of dark brown: first (uppermost) stripe narrow, curved, constituting dorsal profile between level of mouth and first one-fifth or so of second dorsal; in (a) extending, as a continuous line, on to second dorsal from its base anteriorly to near its distal margin posteriorly; in (b), (c) variably represented on fin on the right and left sides, continuous, or in one line plus one or two short streaks, or, on right side of (c), in two subparallel streaks, outer about half as long as inner: second, broadest, curved (convex dorsad), continuous from level of back of eye to end of second dorsal base, on to which it extends: third, nearly as broad, its width about twice interspace between second and third or interspace between itself and fourth, almost straight, from middle of eye to upper border of caudal peduncle, on to which its lower half extends: fourth, somewhat narrower than third, straight, from before eye to upper half of caudal peduncle, its lower border on caudal peduncle coincident with lateral line there; fifth, narrower, straight, from middle of posterior border of orbit on to lower one-third of caudal peduncle, where it becomes more slender, fainter: sixth, narrower still, about half, or less, interspace between itself and fifth, straight, from upper insertion of pectoral, petering out shortly in front of anal termination: seventh, narrowest, least intense, almost straight, from a little behind head, traceable to near hind half of anal, virtually obsolete in (c). The anterior courses of the second and third stripes vary from fish to fish, even somewhat from side to side: in the most regular, presumably 'normal' pattern, as found in (b), the right and left second stripes join immediately in front of the first dorsal origin, embracing it in a neat V, while the two third stripes converge above the eyes, and then run forward parallel, separate by less than width of one stripe, to tip of snout, meeting here a pronounced blackish transverse arc outlining upper lip; in (a) and (c) the arrangement is much less symmetrical, noteworthy variations including some interruption to the third stripe, and the extension forward of dorsal origin of the second, with or without its becoming confluent with the third. The size and disposition of the longitudinal bands in our material are in good overall agreement with those of the bands in Steindachner's figure of *A. strigatus*, reproduced in Whitley (1962, 157) in illustration of *A. mado* Whitley, 1931. Minor variations (other than those of mere intensity in the lower one or two stripes): sixth begins near upper (in figure, lower) insertion of pectoral, general course of those near middle of series somewhat more nearly rectilinear.

First dorsal membrane probably originally yellow, heavily punctulated with brown, between some (possibly originally, most) spines an oblique dark stripe extending from

near base of one spine to near point of attachment of membrane to next spine (in Steindachner's figure these markings appear as light lines). Second dorsal yellow and yellowish distally, brownish, yellowish or whitish proximally; marked with brown as described above. Anal sheath sulphur yellow in two fish, less bright yellow in other; some dark microscopic punctulation, variable in extent and intensity in specimens and on sides of same specimen; projecting tips of rays whitish; membrane between spines yellowish, with or without dark peppering; spines where exposed colorless. Pectoral chiefly whitish with some (probably originally considerably more) yellowish proximally. Ventral in (b) whitish; in others white in basal half or so, dusky distally. Caudal to end of middle rays and on lateral rays to beyond this level, the area being demarcated by an oblique backwardly convex arc, almost uniform yellowish, with some rather faint and imperfect narrow dusky lines, outlining rays; beyond this, wholly white in (b), (c), in (a) white with some duskiness along part of ventral border of inferior lobe.

Genus *SCORPIS* Valenciennes, 1832

Scorpis Valenciennes, 1832, *in* Cuvier & Valenciennes *Hist. Nat. Poiss.*, VIII, ['1831' = 1832], 503. Haplotype, *Scorpis georgianus* Valenciennes.

Scorpis lineolatus Kner, 1865

Scorpis lineolatus Kner, 1865, *Reise Novara, Zool.*, 1, Fische, 1, 108, pl. v, fig. 3. Type locality, Sydney.

Additional records. The inclusion in the Tasmanian list of this species is based on a record in Part XVII (1970, 46) of 7 juveniles taken at Swimcart Beach on 5 May 1968. Additional records: (a) *Ls* 167, *Lt* 228, length to middle caudal rays 188, about 3 km east of Wynyard, 17 June 1972 George Bay (scuba dive; G. Reardon); (b) *Ls* 115, *Lt* 152, length to middle candal rays 132, George Bay, 14 January 1973, K.L. Atherton, Q.V.M. Reg. No. 1973/5/24. The locality of (b) is within less than 10 km of that of the 1968 material: specimen (a) provides the first formal record for our northern coast. Specimen (a) has D. X, 27, A. III, 27; (b) D. X, 26, A. III, 28.

Dorsal and anal spine patterns. The anal spine pattern has been determined for both examples, the dorsal spine pattern for (a) only, some spines being imperfect in (b).

D. Log L = 1.5402 log N + 0.6946. Spine lengths as measured (in parentheses as estimated from the regression equation): 5.0 (5.0), 7.0 (7.2), 8.7 (9.0), 10.9 (10.5), 12.0 (11.8), 13.0 (13.0), 14.0 (14.2), 15.3 (15.2), 16.4 (16.2), 17.0 (17.2). t = 24.95.

A. Specimen (a). Log L = -.4743 log N + 0.6946. Lengths: 10.4 (10.4), 14.5 (14.6), 17.5 (17.5). t = 185.56. Specimen (b). Log L = 0.3572 log N + 0.9002. Lengths: 8.0 (7.9), 10.0 (10.4), 11.9 (11.8). t = 12.68 [$F_{0.05}$ t = 12.71].

Frequency of occurrence. This species is perhaps more abundant here than has hitherto been thought. While *S. georgianus* is readily distinguishable from the two other species in having the soft dorsal and the anal rather strongly produced anteriorly and (normally) in being marked with some four or five dark vertical bars, the distinction between *S. aequipinnis* and *S. lineolatus*, both with soft dorsal and anal rather slightly or barely produced anteriorly, and (normally) lacking dark bars, is not so immediately obvious, and it is probably the two latter species have at times been confused in records of catches at scuba dives. A satisfactory determination can be made by use of the key provided in Part XVII: however, a simple criterion, readily applicable in the field, is the following — in *S. aequipinnis* the greatest width of the expanded posterior end of the maxilla is subequal to, in *S. lineolatus* greater than (usually about twice), direct distance of maxilla from eye.

Family URANOSCOPIDAE

Two species are credited to Tasmania in the Check-list: *Kathetostoma laeve* (Bloch & Schneider, 1801), *Genyagnus monopterygius* (Bloch & Schneider, 1801). The former, known from all Australian States except Queensland, occurs in all Tasmanian lists from the earliest, that of Johnston (1883, 115), who notes its inclusion in the unpublished catalogue of Allport; it is not uncommon in our waters. The latter, the distribution of which is given in the Check-list as Tasmania, New Zealand, Tahiti?, does not appear in any local list; no Tasmanian examples have come under the writer's notice. Two species occurring in South Australia that it would not be wholly surprising to encounter here are *Kathetostoma nigrofasciatus* Waite & McCulloch, 1915, *Ichthyscopus barbatus* Mees, 1960. A *Kathetostoma* identified as *K. giganteum* Haast, 1873, a New Zealand form, is here reported from Coles Bay, Glamorgan, the first record from Australian waters: the determination is based on criteria given by Waite & McCulloch (1915), rather than on those of Haast's original account.

Key to Uranoscopidae Recorded from Tasmania

1 { No spines on preoperculum, on mandible, or in front of ventral fin ..... *Genyagnus monopterygius.*
{ On each side of fish, three spines on lower margin of preoperculum, one on lower portion of mandibular ramus, one in front of each ventral fin ..... 2.

2 { Head and body with broad dark cross bars; not, or faintly and unextensively, marbled. A dark blotch on preoperculum. No white streak along lateral line. (No white spots on body) ..... *Kathetostoma laeve.*
{ Head and body without broad dark cross bars; heavily and extensively marbled. No dark blotch on preoperculum. A white streak along lateral line. (In our specimen, white spots on body) ..... *Kathetostoma giganteum.*

Genus *KATHETOSTOMA* Günther, 1870

Kathetostoma Günther, 1870, *Cat. Fish. Brit. Mus.*, II, 231. Haplotype, *Uranoscopus laeve* Bloch & Schneider.

Kathetostoma laeve (Bloch & Schneider, 1801)

Uranoscopus laeve Bloch & Schneider, 1801, *Syst. Ichth.*, 47, pl. VIII. Type locality, New Holland (Latham) = New South Wales (*fide* McCulloch 1929, 335).

Material. All in collections of Queen Victoria Museum, Launceston. (a) *Ls* 474, Preservation Bay, 6 km west of Burnie, 1 November 1940 (W.J. Beaumont; in seine net), Q.V.M., Reg. No. 1940.2; (b) *Ls* 246, Rowella, River Tamar, 27 February 1941 (T. Hinds; netted), Reg. No. 1941.91 (stomach contents noted in Part V (1941,51); (c) *Ls* 439, Boat Harbour, 21 February 1950 (A.G. White), Reg. No. 1972/5/661; (d) *Ls* 392, West Arm, River Tamar, (Cannon), Reg. No. 1941.55; (f) *Ls* 370, Lefroy, near Currie River, 11 February 1963 (L. McGowan), Reg. No. 1963/5/1; (g) *Ls* 371, Sandy Beach, River Tamar, 9 January 1966 (M. Wells), Reg. No. 1972/5/660; (h) *Ls* 166, Tam-o'-Shanter Bay, 15 May 1968 (J.W. Room); Reg. No. 1968/5/22; (i) *Ls* 197, Table Cape, 20 December 1969, (Morrison), Reg. No. 1969/5/33; (j) *Ls* 111, Coles Bay, 7 April 1975 (E. Scott), Reg. No. 1973/5/90.

Meristic characters. Few quantitative data for this species are available. Meristic observations and measurements of the 10 individuals listed above, made in the course of their comparison with the specimen of *K. giganteum* discussed below, are here recorded. D. 13 (1 specimen), 14 (9). A. 13 (1), 14 (6), 15 (3). P. 18 (7), 19 (2), 20 (1). V.I, 5. C. 9 main rays reaching hind border + (1+1) shorter rays.

Proportions as *TLs*. For each dimension there are given range, mean with standard error, coefficient of variation, and, in parentheses, the value for our example of *K. giganteum*. 'Length to' measurements are taken from most advanced point, tip of chin.

Length to origin, termination of dorsal 523-600, 567.7 ± 5.76, 3.2 (611), 876-964, 912.6 ± 7.08, 2.5 (927); of anal 512-584, 552.1 ± 3.21, 1.8 (581), 905-973, 943.1 ± 5.80 (927). Length to origin of pectoral 190-229, 208.2 ± 3.55, 5.4 (193); length of fin 387-446, 419.7 ± 5.19, 3.9 (386). Length to origin of ventral, at anterior border of girdle 46-69, 58.7 ± 1.81, 9.8 (57), at insertion of spine 96-127, 105.3 ± 2.99, 9.0 (95); length of fin, from anterior border of girdle 244-301, 280.2 ± 5.43, 6.1 (282), from insertion of spine 183-253, 229.2 ± 5.76, 7.9 (186). Length of caudal 205-283, 231.1 ± 7.72, 10.6 (234). Length to vent (middle) 484- 529, 502.1 ± 4.64, 2.9 (541).

Head, to hind border of operculum 283-351, 319.8 ± 6.28, 6.2 (294), to midpoint on hind border of armature 241-270, 253.7 ± 5.14, 6.4 (259). Length to base of humeral spine 380-441, 399.3 ± 6.20, 4.9 (389). Eye, with fleshy rim 28-46, 34.4 ± 1.73, 15.9 (41), without rim 24-42, 31.0 ± 1.76, 22.6 (38). Bony orbit, between midpoints of anterior and posterior borders 37-61, 45.4 ± 1.91, 13.3 (46), between midpoints of lateral borders 34-59, 40.9 ± 2.35, 18.2 (48). Interocular 100-125, 113.3 ± 1.79, 5.0 (98): interorbital (bony) 90-117, 102.3 ± 2.39, 7.4 (95). Snout, from tip of upper jaw 24-43, 32.4 ± 2.09, 20.5 (25), from most advanced point (tip of chin) 75-103, 84.8 ± 3.19, 9.5 (79); the latter origin in advance of the former by 43-66, 56.6 ± 2.53, 14.1 (51).

Depth, maximum 202-259, 217.7 ± 5.14, 7.5 (228), at vent 193-237, 209.4 ± 4.12, 6.2 (209), at caudal peduncle 82-104, 90.3 ± 1.90, 6.7 (87). Width, maximum 345-408, 379.7 ± 6.32, 5.3 (364), at front of eyes 189-264, 239.3 ± 6.82, 9.0 (209), at back of eyes 284-314, 299.7 ± 3.03 (275), at vent 233-314, 273.2 ± 9.45, 10.9 (225).

For the 31 ratios listed the distribution of the number of entries lying within the range $\bar{x} \pm \sigma$ is 5 (5 cases), 6 (9), 7 (8), 8 (7), 9 (2), with a mean of 6.74 (*cf.* the theoretical value in an infinite population with the normal distribution, 6.83).

Variation with size. While statistically significant correlations between *TLs* values of sectional measurements and *Ls* are in general hardly to be looked for in a small tolerably variable sample such as the present, one such case may be noted, that of snout length from most advanced point of fish (r = + 0.78, z = 1.03, t^{**} = 3.95). It is pertinent also to point out that with the series divided into two groups constituted by the smallest 5 and the largest 5 individuals higher mean values of the latter are regularly found for all (3) depth and all (4) width entries, and lower values for all (6) measurements involving eye or orbit.

Cranial armature. Some observations on the nature of the actual sculpturing are made below in the account of *K. giganteum*.

In contrasting their *K. nigrofasciatum* with *K. laeve* Waite & McCulloch state that whereas the hind margin of the cranial plate in the former is 'interrupted by two backward projections', in the latter it is 'nearly straight', features clearly seen in their illustration. Outline figures in Scott (1962, 235) of three uranoscopids show, for *K. laeve*, this margin as being in the general sense straight, with two shallow lateral bays, flanking a median segment itself exhibiting two very slight dips. While the margin in this species is certainly clearly distinguishable from that of *K. nigrofasciatum*, lacking the two pronounced backward processes, it is in our material by no means as straight as in the figures of Waite & McCulloch and Scott, most specimens exhibiting some degree of sinuosity, normally more or less bilaterally symmetrical on either side of a variably developed median proconvexity, and presenting, overall, a well marked forwardly directed arc. Considerable variation in detail occurs; and an occasional individual bears supernumerary ossifications in the form of scattered islets lying a little behind the main plate.

Lateral line. In some individuals the lateral line is traceable with difficulty; where clearly developed it is commonly much as figured by Waite & McCulloch (pl. XIII, fig. 1) for *K. nigrofasciatum* (there does not appear to be an available figure for *K. laeve*), though the pores are sometimes more numerous. Occasionally short closely set ridges, with length up to an eye diameter or more, are developed along the main longitudinal ridge, from which they project outwards and backwards (a few also may project inwards). They are closely beset by, and sometimes perforated by, the pores: in specimen (g) there are 60 (left), 51 (right) such offsets to the point on the caudal peduncle at which the lateral line turns briefly downward, the succeeding segment bearing 10 offsets, followed by 7 large perforations extending well on to base of caudal.

For course of lateral line, see observations on *K. giganteum* below.

Kathetostoma giganteum Haast, 1873

Kathetostoma giganteum Haast, 1873, *Trans. N.Z. Inst.*, V. 274, pl. XVI, fig. 2. Type locality, Heathcote estuary, near Sumner, N.Z.

Material. A *Kathetostoma*, *Ls* 316, *Lt* 390, in the collection of the Queen Victoria Museum, Launceston, Reg. No. 1972/5/617, netted at Coles Bay on 6 November 1972 by Mr R. Standage is strikingly different from all specimens of *Kathetostoma laeve* examined. It is here determined, somewhat provisionally, as *K. giganteum* Haast, 1873, not hitherto reported from Australian waters.

Meristic features. D. 17. A. 16. P. 20. V.I,5. C. 9 + (1+1).

Proportions. A set of 31 proportions as *TLs* has been included, for typographical economy, with the corresponding data for *K. laeve*, above. Additional *TLs* measurements of fin rays: longest (4th) dorsal 139; longest (14th) anal 120; longest 'free' pectoral (9th from below) 318, longest (11th) pectoral 322, uppermost pectoral 282; pelvic, in succession from innermost, 204, 212, 182, 138, 98, spine 63.

Coloration. This is strikingly different from that of *K. laeve* or of *K. nigrofasciatum*.

(a) Trunk. Dorsal surface in advance of dorsal fin predominantly bluish, (this blue color, however, is due to a superficial, possibly adipose film, removal of which reveals a ground coloration beneath similar to that behind level of dorsal origin); five whitish and five smaller blackish blotches, nearly a score of clearly delimited mostly round white spots, modally about 2 mm, a sprinkling of smaller ones; behind dorsal origin whitish ground, heavily mottled and maculated with brownish and bluish brown, the irregular markings mostly 1-7 mm, on right side only two small white spots. Lateral surface for short distance behind head with downward extension of the bluish from anterior dorsum; rest, in general, resembling dorsum behind dorsal origin; mottlings constituting an overall dark area, about 30x20 mm, below dorsal fin, in advance of this smaller, less compact, behind even more so; markings extending down about half depth of flank anteriorly, about two-thirds on caudal peduncle, becoming less extensive, less intensive ventrad. A white streak along the whole length of the lateral line. Ventral surface behind level of pectoral wholly whitish; rest to level of front of pelvic girdle evenly dusky, save for small whitish patch, about 15x20, behind pelvic insertion.

(b) Head. Armored region mainly light brownish, with some black spots and short dashes. Laterad of armor, continuing down nearly to ventral profile, like most of side of trunk; soft interorbital area dark bluish brown with transverse arc of off-white; no dark patch on operculum or preoperculum; frontal aspect slaty in upper half, whitish in lower half with some bluish brown splashes. Upper lip mainly bluish brown and brown, a very narrow white anterior border, lower lip with more brown. Inside of mouth white or whitish; tongue dead white.

(c) Fins. Dorsal membrane greyish; an imperfect narrow border of whitish; dusky along distal one-fourth of first half dozen rays; dark bar or splash between outer parts of some rays; free tips of rays yellowish. Anal membrane mostly concolorous with adjacent flank; a dusky area beneath last half dozen rays; stout free tips of rays conspicuously white (on right three rays, on left one, with basal black mark). Pectoral with proximal two-thirds or so, except near upper and lower borders, darkish grey, spotted with darker; borders of basal portion and, except for a wide irregular marginal band of whitish, all distal portion darker, about concolorous with proximal spots; stout free tips of lower rays conspicuously white; internal surface of fin much like external: base of left fin with upper half smooth, white, immaculate, lower half deep greyish; of right fin mostly whitish, upper one-third with a few, rest with a good many, darkish spots. Caudal greyish, with scattered darker patches, several nearly black; most of uppermost ray, much of lowermost, dark, in part black; a subterminal arc of about a score of short (about 5 mm) subrectangular dark markings, some on rays, some on membrane; a light terminal band (3-5 wide) across whole border, membrane whitish, rays pale somewhat greenish yellow.

Discussion. In general structure and proportions this fish agrees closely with *K. laeve* as that species is represented by our material: it differs strikingly from it in color pattern, and, less notably, in some other features. In their account of *K. nigrofasciatum* Waite & McCulloch state their species, *K. laeve* and *K. giganteum* can be satisfactorily identified by a key based solely on color pattern (one criterion for *K. giganteum*, 'a white stripe along the lateral line' is not noticed in Haast's original description). By this key the present fish clearly comes out as *K. giganteum*.

There are, however, several difficulties. Haast's figure (an outline sketch) shows the anal as beginning behind, and having a shorter base than, the dorsal: in *K. laeve*, *K. nigrofasciatum* and the present specimen the anal begins in front of the dorsal and has the longer base. The dorsal, anal and pectoral counts of the Coles Bay specimen do not agree in toto with the counts for *K. giganteum* (D.16:A.16:P.22; Haast), the counts for *K. laeve* (D., our material 13-14, Scott (1962, 17) 15-16, early writers (e.g., Macleay, 1881a, 562; Johnston, 1891, 33) 17: A. 13-14, 15-16, 17, respectively: P. 18-20, 15-16, respectively), the counts for *K. nigrofasciatum* (D. 13-14: A. 13-14: P. 19 (Scott), in part extending the typical 14, 14, 19). It may be observed that on the basis of dorsal count our specimens of *K. laeve* would be referable, according to the key by Scott (1962: 245), to *K. nigrofasciatum*.

According to Waite & McCulloch, the exposed cranial bones are sculptured into reticulating ridges in *K. laeve*, and into tubercles in *K. nigrofasciatum*, while in *K. giganteum* ('head partly rugose and covered with numerous grains', Haast) the sculpture is granular. No example of *K. nigrofasciatum* is at hand. However, any suggestion that the sculpturing in *K. laeve* consists wholly of reticulating ridges is not borne out by our material, which presents a variety of elevations reasonably describable as ridges (separate and confluent), tubercles and grains; the first being the most abundant. Hence it is not possible to draw, on the basis of nature of relief, an absolute line of demarcation between *K. laeve* as found and *K. nigrofasciatum* as described. However, in the Coles Bay fish, while some elevated lines are present in the main (postocular) cephalic plate (trenchant ridges occur in the preorbital in all species), the modal relief element is a boss rather than a ridge, making feasible a quantitative, if not a strictly qualitative, distinction from *K. laeve*.

The distinction between the two species is aided by the starlike formations noted by Haast. The most conspicuous of these are two paired sets of lines, constituted chiefly of grains, radiating, on each side of head, one from a point shortly behind posterointernal projection of bony orbit, the other from a point almost directly behind this near the hind border of the armor, the transverse distance between members of each pair being rather greater than the anteroposterior interval between pairs. On each side the radiations from the two centres together form a figure resembling a karyokinetic spindle. The inner halves of the two spindles occupy most of a somewhat depressed rectangular region lying behind the smooth unarmored interorbital space. In *K. laeve* somewhat similarly

disposed striae, more or less regularly directed outwards from the centre of this rectangle, are often traceable; but the spindle elements outside the rectangle are not recognizable. In the Coles Bay fish there occur, on each side, two other, less conspicuous, less extensive systems of radiating lines of bosses, one with centre just laterad of the posteroexternal angle of bony orbit, the other behind and somewhat laterad of the first, close to hind border of cephalic plate.

Family GNATHANACANTHIDAE

Views on the familial status of the fish now known as *Gnathanacanthus goetzeei* Bleeker, 1855 — notable synonyms of which are *Haloxenus cuteneus* Gunther, 1876, *H. guntheri* Johnston, 1883 (both with Tasmania as type locality), *Beridia flava* Castelnau, 1878 (Victoria) — have varied. Bleeker and Boulenger referred it to the Scorpaenidae, Gunther with some doubt placed it among the Cirrihitidae, Macleay listed it, as Gunther's species among Scorpaenidae (species 299), as Castelnau's with platycephalids and triglids in the old broad Cottina (species 466), Johnston in 1883 included it in Triglidae, in 1891 in Scorpaenidae. By recent Australian authors *S. goetzeei* has been treated as the sole representative of its family, Gnathanacanthidae. However, Greenwood *et al.* (1966) in their provisional classification of living teleosts subsume Gnathanacanthidae in Pataecidae. There is certainly considerable superficial similarity between on the one hand *Gnathanacanthus* and on the other the genera of the Pataecidae *sensu stricto* (*Pataecus* Richardson, 1844, *Neopataecus* Steindachner, 1884, *Aetapcus* Scott, 1936). And while there is undeniably much to be said in favor of a general policy of overall reduction in the large assemblage of families that have from time to time been proposed, a good case also can be made out for the retention of a family, even though monotypic, if the relevant form presents a constellation of taxonomically significant characters no one of which is exhibited by any of the other forms. Noteworthy differences between *Gnathanacanthus* and the pataecids *s.s.* include: ventrals present (absent in pataecids); dorsals separate, or virtually so with a deep notch between them, each rising to its greatest height near its middle (dorsals wholly united, combined contour nearly straight or a continuous fairly gentle curve); second dorsal subequal to (shorter than) first, with several (no) spines; anal base subequal to (much less than) first dorsal base. Osteological data are unavailable: on the basis of general external features, the writer would be inclined to favor the retention of Gnathanacanthidae.

Genus *GNATHANACANTHUS* Bleeker, 1855

Gnathanacanthus Bleeker, 1855, *Verh. K. Akad. Wet. Amsterdam*, ii, 21. Haplotype, *G. goetzeei* Bleeker.

Gnathanacanthus goetzeei Bleeker, 1855

Gnathanacanthus goetzeei Bleeker, 1855, *Verh. K. Akad. Wet. Ansterdam*, ii, 21. Type locality, Tasmania.

Material. Some observations are here made on five individuals: (a) *Ls* 190, *Lt* 260, Bicheno, 26 February 1959, F.J. White; (b) *Ls* 235, *Lt* 315, east coast of Cape Barren Island, Bass Strait, 2 July 1969, B. Greeno, Q.V.M. Reg. No. 1969/5/28; (c) *Ls* 256, *Lt* 320, Ocean Vista, West Burnie, 2 October 1972, C. Jones and P. Van Der Woude, Q.V.M. Reg. No. 1972/5/605; (d) *Ls* 218, *Lt* 288, off Eddystone Point, 27 December 1972, G. Allen (netted over gravel), Q.V.M. Reg. No. 1973/5/5; (e) *Ls* 201, *Lt* 206, Tamar River estuary, 17 September 1973, E. Porter and A.W. Hesketh, Q.V.M Reg. No. 1973/5/109.

Meristic characters. (Specimens in sequence as above). D. VII; V, 9: VIII; III, 10: VII; IV, 10: VII; III, 10: IX; IV, 9. A. III, 8 (all specimens). P. 11: 10 left, 11 right: 11: 11: 12. C. 12+2: 9+3: 12+2: 10+2: 10+2. V. I, 5.

In describing his material Johnston (1883, 114) listed it as *Holoxenus cutaneus* and expressed the opinion it was probably correctly attributed (noting that if a new species was involved he proposed for it the name *H. guntheri*), but called attention to noticeable differences between his dorsal and anal formulae and those of Günther.

The variation in the dorsal count may be considered first. Along with those for our five specimens there may be noted those reported by Günther (1876) *(Holoxenus cutaneus)* VII; III, 10, Johnston (1883) *(H. guntheri)* VIII; V, 10, Castelnau (1878) *(Beridia flava)* VII; III, 10 (in generic diagnosis VIII), Waite (1929) VII; V, 9, Scott (1962) (synoptic) VII; III, 10-11. So marked a variation in spine counts (VII-IX in first dorsal, III-V in second; overall 10-13 items) appears somewhat surprising. It is pertinent to note the two dorsals are variously reported either as being wholly separate (interdorsal not exceeding an eye diameter, according to Castelnau's account and plate), or as being 'separated by' a small space while being 'connected by a very low membrane' (Waite). Examination of our material discloses the following situation: where the space between the last largish spine (7th or 8th) of the first dorsal and what may conventionally regarded as the first spine of the second dorsal is bridged by a relatively low, but distinct membrane it will normally include one or two spines; where the membrane is obsolete or obsolescent (the interval between successive spine bases here ranging from rather less than to more than twice the diameter of the eye) there occur one or two small white-tipped non-rigid papillae that appear, by location and appearance, clearly to be rudiments of spines. Accordingly as these remain small soft projections (the height of which may not much exceed a millimetre) or develop into recognizable spines, of varying lengths, the first dorsal count is likely to be recorded as ranging from VII to IX. Furthermore, while the initial spines of the second dorsal are sometimes recognizable as such by being set more closely together than the terminal spines of the first dorsal, as in the specimen figured by Waite, this arrangement is not always apparent; it is hence by no means impossible that the nominal differentiation between the two dorsals, if based wholly on a determination, not always readily made, of the lowest point on the membrane, where this is present, may at times be an arbitrary one, with the possibility of a spine, or spines, being allotted to either section of the fin.

In the anal Günther recorded 9, noting no spines, while Castelnau in the diagnosis of *Beridia* states the anal has one spine, but he describes and figures his type specimen of *B. flava* from Portland Bay, Victoria as having two spines. The normal count is III, 8-9, and it may be surmised Günther's notation is simply a slip, while Castelnau's II is either derived from an unusual specimen or is also an error. The pectoral has 10,11 (modally) or 12 rays. Castelnau describes and figures one upper branched ray plus nine simple rays: Waite states all rays are simple, but notes the upper two are conjoined at the base. Conjunction or very close approximation appears to characterize our material: however, the partial concealment of the rays by thick membrane may lead to there being the appearance of a single ray bifurcated in its distal two-thirds or so. The caudal is variously described and figured as having 10-14 rays. The norm is two moieties each of 5 or 6 rays reaching to the hind border, supplemented by two flanking shorter rays, one above, one below. As in the fins in general the anal rays are characteristically simple, though Castelnau notes and figures one divided ray. In the present specimens the caudal is rounded, as in Waite's plate, not straight, as in Castelnau's.

Dimensions as *TLs*. The data are for (a)-(e), in that order. Length, to origin, termination (last spine) of: first dorsal 150, 149, 148, 183, 149; 511, 447, 441, 495, 498: second dorsal (spine-ray) 526, 562, 551, 569, 567; 884, 851, 863, 922, 801: anal (spine-ray) 539, 566, 621, 660, 602; 863, 847, 832, 807, 826. Length to origin of: pectoral 237, 268, 273, 275, 249: ventral 266, 298, 320, 317, 269. Length of: pectoral 395, 349, 355, 393, 363: ventral 337, 294, 277, 307, 264. Head 392, 396, 359, 427, 408. Snout 129, 116, 111, 138, 129. Eye (full) 48, 64, 59, 69, 70; (free of membrane) 26, 30, 35, 34, 29. Interorbital 76, 89, 94, 78, 80. Depth at: front of eye 289, 238, 219, 289, 282; back of eye 326, 311, 313, 358, 335; opercular border 368, 383, 336, 413, 433; vent 405, 336, 340, 394, 398: maximum depth 405, 383, 340, 413, 448: depth of caudal peduncle 92, 86, 79, 89, 81.

Comparative proportions. A comparison of our material with that of Waite in respect of the proportions he records is here given (Waite's values in parentheses). Head 2.55, 2.53, 2.78, 2.34, 2.45, (2.2); depth 2.47, 2.61, 2.94, 2.42, 2.23, (2.6); length of caudal 2.71, 2.84, 3.84, 3.11, 3.40, (2.4), in standard length. Eye (for our specimens

first entry is total diameter, second diameter of exposed portion) 8.28, 14.9; 6.20, 13.3; 6.13, 10.2; 6.20, 12.7; 6.23, 14.1, (9.5; measurement convention not specified; on basis of figure, probably exposed region); interorbital 5.14; 4.43, 4.18, 5.47, 5.13 (7.7); snout 3.04, 3.32, 3.23, 3.10, 3.15 in head. Longest dorsal spine — (imperfect), 1.57, 1.43, 1.72, 1.61 (1.7); longest dorsal ray 1.31, 1.23, 1.62, 1.36, 1.32 (1.36); second anal spine 3.39, 3.51, 2.97, 3.58, 3.04 (2.8); longest anal ray 1.55, 1.41, 1.44, 1.35, 1.58 (1.6) in head.

Other features. Comparison of some non-metrical features in Waite's account of his Victorian specimen and in the Tasmanian examples reveals good overall agreement: variations, if any, shown by our fish are noted in parentheses. Maxilla extends to 'below first third of eye' (in (a) somewhat beyond middle of eye, in (b)-(e) short of eye by 0.1-0.3 eye diameter); dorsal commences at the angle over the eye; third dorsal spine longest; third and fourth (fourth) dorsal ray longest; dorsal and anal terminate almost evenly (fairly evenly, but some difference, according as determined by points of insertion of last rays or by termination of membrane); fourth and fifth anal rays longest, equal (fourth exceeds fifth); spine, second ray, third ray of ventral equal (subequal) to second spine and to fourth, fifth rays of anal. Waite records 4+8 gill rakers on anterior arch; noting 'the first four of the lower limb are paired' (in one fish 5, in the remainder all 8, of the rakers of the lower limb are paired; the inner rakers being smaller than the outer, with the interval between them about equal to the basal width, whereas the outer are contiguous or almost contiguous basally, and set nearly at right angles to the outer, upper series, thus projecting more or less horizontally into the pharynx. Neither Waite nor Castelnau makes mention of a large strong membrane — noted in Scott (1962, 164) — that joins the inner rays of the ventrals, and attaches them to the body, along which it extends on either side as a well developed slip about to level of vent, and as a ridge, becoming progressively obsolescent caudad, about to level of anal origin. The extent of the membranous junctions of the dorsal and anal with the caudal peduncle varies a good deal, ranging between the extremes shown in the figures of Castelnau and Waite.

Coloration. The fish, which always presents a bright appearance, is reported either as being unicolor (scarlet, deep purple, bright red, orange, yellow) or as exhibiting a combination, in varying proportions, of one of the reddish and one of the yellowish hues. Specimens (e) and (a) provide examples of the two types.

In the Tamar River specimen, (e), the whole body is a virtually uniform dark rich 'tapestry' red. Head not differing sharply from body, being slightly brownish red; all fins concolorous with head, though on being held up to the light they approach the richer, almost glowing body color.

The following notes on the Bicheno specimen, (a), were made quite shortly after capture. Head wholly rich red, apart from a median strip on forehead, from mouth to dorsal origin, the hind part of the chin, and the whole throat, which are bright yellow. Body wholly rich red, save for an extension of the yellow of the throat to below, and on to the base of, the pectoral. First dorsal more than half covered by a continuation of the head red; between first and second spines continuous red of any intensity confined to basal one-sixth, rest of membrane yellow with small red spots; between second and third spines similar, but spots more numerous; between third and fifth spotting much more profuse, giving a predominant effect of red, extending from base to within 2-5 mm of free border; between short posterior spines continuous red. Second dorsal, proximad of a line from about tip of second spine to near base of last ray, red; distad of this line yellow; membrane behind last ray almost entirely red. Anal, proximad of an upwardly concave line from near tip of first ray to middle of last ray, red; rest yellow. Ventral with about proximal one-third, pectoral with about proximal two-thirds red; rest of these fins yellow.

Spine and ray patterns. These have been investigated in the Eddystone Point individual, and it has been found possible to specify the lengths of all spines and rays (one caudal ray imperfect) as a function of their serial insertion along the fin base (see Part XIX

for a general discussion of these length-number patterns). While a conventional origin and a conventional direction for the counting of the radial elements were specified in Part XIX for dorsal, anal, pectoral and ventral fins, no such conventions were there laid down for the caudal. It is here stipulated that in these investigations the formal first caudal ray is the dorsalmost ray and that the rays are counted from this ray continuously to the ventralmost (the frequency in the caudal of a bilateral symmetry of course suggested a possibility of treating the fin as composed of two moities with separate notations — however, the formulation adopted is evidently of a more general character, and is, moreover, in accord with the paradigms for the other fins).

Sets and subsets of the radial elements of this fish are as follows (as before, capitals denote spines, lower case letters rays).

$D = D_1 \quad D_2 \quad D_3 = \quad : D_1 = \quad x/x$ = I-III of first dorsal ; $D_2 = \quad x/x$ = IV-VII of first dorsal ; $D_3 = \quad x/x$ = I-III of second dorsal . $d_1 \quad d_2 \quad d_3 = \quad : d_1 = \quad x/x$ = 1-4 ; $d_2 = \quad x/x$ = 5-7 ; $d_3 = \quad x/x$ = 8-10 .

$A = \quad x/x$ = I, II, III . $a_1 \quad a_2 = \quad : a_1 = \quad x/x$ = 1-4 ; $a_2 = \quad x/x$ = 5-8 .

$v = \quad x/x$ = 2-5 . (No formulation for ray 1 or spine). (Left fin measured).

$p = p_1 \quad p_2 = \quad : p_1 = \quad x/x$ = 1-4 ; $p_2 = \quad x/x$ = 5-8 . (Left fin measured).

$c = c_1 \quad c_2 = \quad : c_1 = \quad x/x$ = 1-6 ; $c_2 = \quad x/x$ = 8-12 , 7 imperfect .

Below there appear, for each subset, first, the regression equation for log spine or ray length on log serial number; secondly, measured lengths, mm, of the members of the subset (with, in parentheses, estimated lengths computed from the equation); thirdly, the t value.

D_1. Log L = 0.4365 log N + 1.5268. 33.5 (33.6), 46.0 (45.5), 54.0 (54.3). t = 18.39.

D_2. Log L = 0.70489 log N^1 + 1.2537. 17.9 (17.9), 29.1 (29.2), 39.7 (38.9), 47.0 (47.6). t = 41.49.

D_3. Log L = 0.6564 log N + 1.1986. 15.8 (15.8), 24.9 (24.0), 32.5. (32.5) t = 415.00.

d_1. Log L = 0.1764 log N + 1.7387. 54.6 (54.8), 62.0 (61.8), 67.0 (66.4), 69.2 (69.8). t = 20.56.

d_2. Log L = 0.2388 log N^1 + 1.6987. 49.9 (50.0), 59.2 (59.0), 64.8 (65.0). t = 38.14.

d_3. Log L = 0.7737 log N^1 + 1.1777. 15.0 (15.1), 26.0 (25.7), 35.0, (35.2). t = 48.77.

A. Log L = 0.6153 log N + 1.2340. 17.2 (17.1), 26.0 (26.3), 33.9, (33.7). t = 43.03.

a_1. Log L = 0.08949 log N + 1.7829. 60.9 (60.7), 64.0 (64.5), 67.0 (66.9), 68.9 (68.7). t = 15.27.

a_2. Log L = 0.6966 log N^1 + 1.3610. 23.1 (23.0), 36.9 (37.2), 48.9 (49.4), 61.0 (60.3). t = 8.14.

v. Log L = 0.3430 log N + 1.5609. 36.6 (36.4), 45.6 (46.1), 53.0 (53.0), 58.9 (58.5). t = 24.18.

p_1. Log L = 0.2082 log N + 1.7509. 55.9 (56.4), 66.1 (65.1), 71.0 (70.8), 74.5 (75.2). t = 15.53.

p_2. Log L = 0.3575 log N^1 + 1.5505. 36.0 (35.5), 44.1 (45.5), 52.2 (52.6), 58.6 (58.3), 64.9 (63.1), 68.1 (67.4), 70.0 (71.2). t = 16.37.

c_1. Log L = 0.1810 log N^1 + 1.7168. 50.9 (52.1), 60.7 (59.1), 65.6 (63.6), 67.2 (67.0), 69.0 (69.7), 71.0 (72.0). t = 10.54.

c_2 Log L = 0.1681 log N^1 + 1.7281 — (—) [imperfect], 60.2 (61.3), 64.0 (64.3), 67.6 (67.5), 70.2 (70.1), 72.2 (72.3). t = 14.93.

Family ALUTERIDAE

In Part IX (1960) there was presented a key to 16 species reported from Tasmania — this formulation was based largely on synoptic ad hoc data from available descriptions and figures, and was noted as being of a decidedly provisional character. The Tasmanian leatherjacket fauna remains in urgent need of revision, and at the present time no satisfactory census of it can be made.

Since the publication of that key, one item, a new species, *Brachyluteres wolfei* Scott, 1969, has been added to the list; a South Australian form, *Navodon multiradiata* (Günther, 1870) is here recorded. From *Brachyluteres trossulus* (Richardson, 1846), appearing in the key in section B, the new species may be distinguished by having dorsal spine originating behind (*cf.* before middle of) eye, by higher fin counts for dorsal and anal, 27, 25 (24, 22), and by lacking black specks and white or blue spots tending to form lines on lower part of body. *Navodon multiradiata* is separable from both species in section G of the key, there listed as *Meuschenia trachylepis* (Günther, 1870) and *Navodon hippocrepis* (Quoy & Gaimard, 1824), by the following characters: dorsal spine inserted behind (*cf.* above or before) middle of eye, spine not received (received) into a groove when depressed (this last feature also separates off another species, *Acanthaluteres brownii* (Richardson, 1846) with spines (4) on caudal peduncle); gill opening almost wholly behind (wholly or mostly below) eye; distinctive color patterns.

Genus *NAVODON* Whitley, 1930

Navodon Whitley, 1930, *Aust. Zool.*, vi, 2, 179. Orthotype, *Balistes australis* Donovan.

Navodon multiradiata (Gunther, 1870).

Monocanthus multiradiatus Gunther, 1870, *Cat. Fish. Brit. Mus.*, viii, 248. Type locality, South Australia.

Tasmanian record. Two examples, (a) *Ls* 260, *Lt* 320, Q.V.M. Reg. No. 1973/5/11, (b) *Ls* 267, *Lt* 329, Q.V.M. Reg. No. 1973/5/12, from about 3 km east of Wynyard, 7 January 1973, North West Scuba Club (P. Van Der Woude).

The species was originally described from a stuffed and dried specimen, the color being given simply as 'uniform brownish grey'. In his South Australian catalogue Scott (1962, 316), who states it is not uncommon in the neighborhood of Dangerous Reef, off Port Lincoln, notes some additional morphological characters, and provides some observations on the color in life: a more detailed account is here offered. The Check-list records it (as *Meuschenia multiradiatus*) only from South Australia. Though here for the first time formally reported from this State, it is tolerably familiar to local scuba divers under the name of Spinytail (a name possibly applied, however, also to other species).

Fin counts. (Reported range in parentheses). D. 35, 35 (34-36). A. 33, 33 (32-35). P. 14/14, — / 13 (13). C. 12, 12 (12).

Proportions as *TLs*. Length to origin, termination of first dorsal 275, 270, 381, 378; of second dorsal 527, 509, 885, 865; of anal 585, 588, 907, 899. Length to pectoral 315, 301; length (full) of fin 125, 124; vertical extension of base 58, 56. Length to vent (middle) 575, 577. Head to lower end of gill opening 292, 273; to upper end 315, 300. Snout 235, 225. Eye 62, 56. Interorbital 80, 75. Oblique length of gill opening 77, 71; of mouth cleft 54, 58. Direct distance from eye to gill opening 87, 82; to horizontal level of profile 31, 26; to nostril (middle) 38, 40; to base of dorsal spine 46, 37. Internarial 46, 49. Depth at gill opening 358, 352; at second dorsal origin

375, 371; at vent (middle) 358, 352 (maximum depth): depth of caudal peduncle 88, 96. Length of dorsal spine — , 199; of first, longest, last rays of dorsal 46, 41, 100, 105 (about middle), 42, 48; of anal 57, 39, 104, 103 (about middle), 54, 54; of pectoral 43, 46, 87, 77 (4th-5th), 50, 55: direct length of longest (outermost) caudal ray 235, 228, of shortest (middle) 150, 161. Length of pelvic spine 13, 17; basal diameter 11, 11: direct distance from spine to vent (middle) 63, 60.

Description. Rather elongate, robust; greatest depth 2.6, depth at anal origin 2.3, in *Ls*; not greatly compressed, maximum width half depth at anal origin. Dorsal profile more or less a single moderately convex sweep with slight local extra convexity above eye and some flattening at interdorsal; anal profile subequal to dorsal, the ventral flap small, not extending far below level of beginning of tail. Pelvic spine well developed, reaching to within less than one and a half eye-diameters of vent; ventral spine small, mounded, length about one-fourth to one-third eye, with cluster of closely set blunt spinules, its distance from vent (middle) about equal to eye. Caudal peduncle shortish, rather stout, its depth subequal to interval between bases of last dorsal and uppermost caudal ray.

Head moderate, its length to top of gill opening 3.2-3.3 in *Ls*. Snout 1.3 in head, tip bluntly rounded. Eye 5.1-5.3 in head, close to dorsal profile, vertically below it by its own diameter. Interorbital moderately convex anteroposteriorly, strongly so transversely, 1.3 eye, one-fourth length to pectoral. Gill opening oblique, its lower end at, or barely anterior to, its upper end slightly behind, posterior border of orbit; its oblique length a trifle less than its distance from orbit, subequal to interorbital width. Nostril a little above level of middle of eye, its direct distance from orbit 1.4-1.6 in eye diameter, a little greater than its direct distance from its fellow. Mouth cleft somewhat oblique, its length subequal to eye. Teeth in lower jaw 4, large, wide, flattened, the anterior pair larger, each with a deep groove basally on labial surface; teeth in upper jaw 6, outer 4 small chisel-like, inner 2 subtriangular, much larger, though half, or less, size of median pair of lower jaw, the latter apposing all 6 of upper jaw.

Dorsal spine fully erectile; when depressed, not received into a groove (interdorsal somewhat concave mesially in its anterior half, but no groove here); originating just behind middle of eye; curved a little proximally, its distal three-fifths virtually straight; its length 1.2 interdorsal, about half maximum depth of body; rather slender, compressed anteroposteriorly, its thickness at base about three-fourths, at middle of length about half, its width there; posterior surface flattened; anterior surface strongly convex transversely, bearing in most of distal half two rows of small, largely recumbent spines, separated by a narrow well-marked groove, the spines becoming obsolete and the groove disappearing in the proximal half, the whole surface thickly beset with small elevations, mostly mammilloid, of several sizes, disposed partly at random, but in places arranged in two or three imperfect rows on either side; each lateral border with a row of about a score of subconical spines, slightly recurved, projecting outwards and downwards, the largest, occurring shortly above the base, about 2 mm long, set about twice its length from next spine, length of spine and interval between spines both noticeably decreasing distad.

Second dorsal originating at about middle of standard length, terminating above fourth anal ray from end; subrectangular, the rays, other than three or four at either end, of nearly the same length; longest ray, near middle of fin, 1.6-1.8 eye; rays simple; between successive rays membrane gently excavate. Anal originating below sixth dorsal ray; similar in form to that fin. Pectoral situated wholly behind vertical from eye; its length 2.4-2.5 in head; upper half rounded, lower half continuing in a slower curve; longest (4th-5th ray) 1.4-1.6 eye; vertical extent of base subequal to eye, midpoint of base level with, or a trifle below, bottom of gill opening. Caudal slightly emarginate, gently sinuous, with one median convexity, two lateral concavities; longest (outermost) ray about four-fifths head, 1.4-1.5 shortest (middle) ray.

On middle of caudal peduncle on each side, in (a) 6 stout subconical forwardly curved spines, 3-3.5 mm long, in 3 pairs, about their own length apart longitudinally, rather more than this transversely: in (b) 4 spines only, somewhat stouter, less hooked; on both sides, more pronouncedly on the right, each lower spine inserted in advance of the upper member of the pair, its normal position being vertically below it. While 6 is the modal number, instances of 4, 5 or 6 have at various times been noted in the field. The species is described as having 'short bristles on the side of the tail' (Gunther), 'a small patch of very short bristles in front of the spines' (Scott). Our specimens present no macroscopic bristles, but just in advance of the spines an ill-defined subelliptical region, its major (longitudinal) axis about two-thirds eye, bears numerous almost microscopic projections, mostly black, many tipped white, that appear to differ little, except in size, from the microscopic spinules of the scales. Most of latter surmounted by a rounded fleshy papilla; on head irregularly disposed, larger, more closely set just behing light circumoral band; on trunk in a line along scale border, in most parts modally 7 in a series, but on most of flank behind about middle of anal base commonly 3-5.

Coloration. The stuffed type was described as uniform grey; a lighter area at base of caudal spines and at hind margin of caudal: our formalin material shows remains of color pattern as follows. General color darkish grey on back and flank down about to level of gill opening, with a less intense extension downward behind head to near ventral profile; elsewhere lighter; a putty-colored circumoral ring; widish raised rim of vent off-white; between snout and vent four longitudinal series of dark markings, anteriorly mostly of spots or more or less rounded blotches, posteriorly coming to form short bars and some tolerably long lines, more or less continuous behind vent with several longitudinal series alongside anal base; two or three similar series along dorsal profile backwards about from level of dorsal spine to origin of second dorsal, with indications of extension to near end of fin; membrane of first dorsal only partly preserved in both specimens, remnants blackish, with some lighter spots; second dorsal and anal membranes virtually uniform pale yellowish, rays a trifle deeper; pectoral membrane hyaline, rays light yellowish; outer rays of caudal blackish, inner whitish and/or greenish, membrane between outer rays blackish, between inner rays either blackish throughout or only distally; a large yellowish semilunar terminal area, extending whole width of fin, its median anteroposterior extent a little less than an eye diameter.

Field notes on two fresh examples (near Wynyard, Wellington, 17 June 1972): light greenish, some diffuse yellow round bases of caudal spines; blue markings round eye; blue circumoral ring, lips lighter; gold reticulations and lines on snout, continued on to lower flank as far back as vent, lines becoming further apart caudad; along anal base two blue, two gold lines; first dorsal blue marbled with black; second dorsal and anal bright yellow; pectoral yellow, somewhat olivaceous; caudal mostly dark greenish, light bluish area distally.

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THE VEGETATION OF THE RHEBAN SPIT, TASMANIA

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(with one table, three text-figures and four plates)

ABSTRACT

The vegetation of the Rheban spit, Tasmania is described and discussed. The vegetation on the frontal dunes, which have largely been developed in the last twenty years, can be divided into three zones, one dominated by *Ammophila arenaria*, one dominated by small herbs, and one dominated by *Pteridium esculentum* and *Banksia marginata*. The beach ridge vegetation cannot be divided so clearly into zones, but continuous variation is demonstrated through the use of polar ordination. The saltmarsh vegetation is briefly described, and the case for the preservation of the vegetation of the spit outlined.

INTRODUCTION

There are few accounts of the coastal vegetation of Tasmania. Stephens and Cane (1938) superficially described the vegetation and soils of the north-east coastal region, and Davis (1941) published a preliminary account of the vegetation of the New Harbour area in the south-west of Tasmania. This article describes the vegetation of the Rheban spit which is located approximately 10 km south-east of Orford on the east coast of Tasmania (figure 1).

The spit consists of a set of frontal dunes, backed by sets of lower, subparallel beach ridges, which are bounded to the west by a tidal lagoon. The maximum width of the frontal dunes is at present 140 m, while the beach ridges extend at their maximum 650 m inland from their contact with the frontal dunes.

No climatological data are available for the spit itself but the precipitation data from Triabunna and the temperature data from Swansea (table 1) probably approximate conditions on the spit.

The Rheban area was first settled in the late nineteenth century. The spit has been used, at least in recent years, for rough grazing in winter when the marsh areas become too waterlogged for this activity. The northern portion of the spit was cleared between 1946 and 1966, and there is evidence of firing, probably initiated to improve grazing on the uncleared part of the spit. Both the spit and the adjoining tidal lagoon are included in a sanctuary, but while the area remains private land, subject to grazing, clearing and firing this status affords little protection for the flora and fauna.

METHODS

The transect C-D (figure 1) was surveyed with a dumpy level and Carr-staff. Two pits were dug to observe soil characteristics, and these data were augmented through hand augering to a depth of 1.7 m at twenty-four localities along the surveyed line. Horizon depths, soil colour and soil texture were recorded.

The vegetation was sampled at twenty-four localities along the surveyed line (Figure 2). Each sample area consisted of ten one m^2 quadrats, aligned with the ridges and swales, each quadrat being separated by one metre. All species of vascular plant occurring within each quadrat were recorded. A plant was considered to be present in a quadrat if any of its aerial organs were situated directly above the quadrat. This

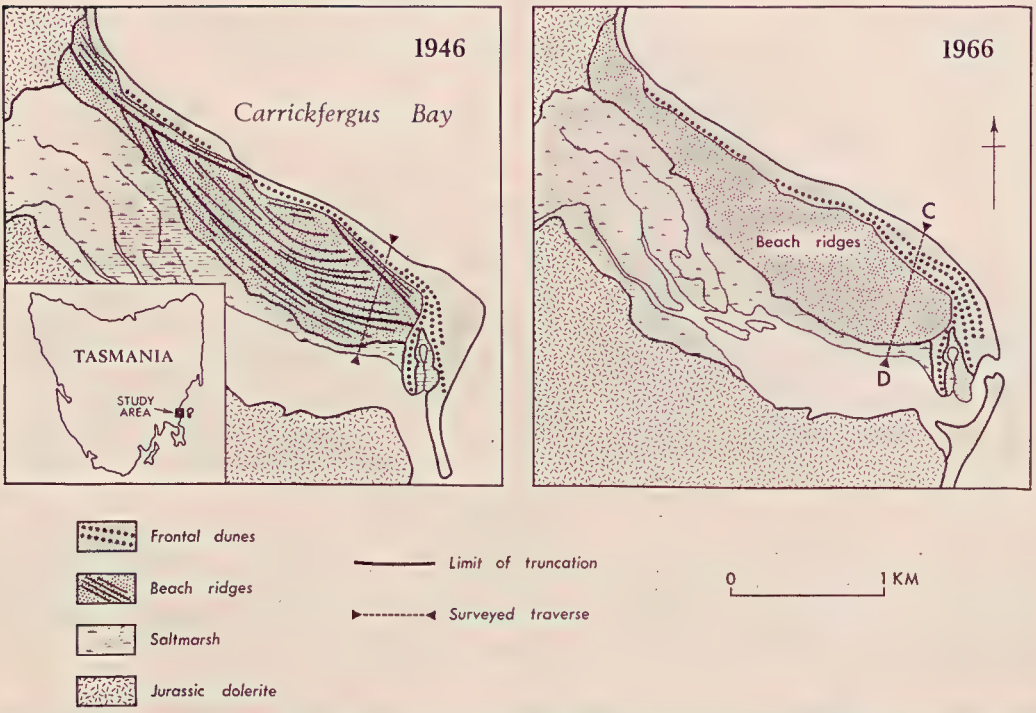

FIG. 1.- The Rheban spit, showing its evolution between 1946 and 1966 and the location of the transect.

TABLE 1

CLIMATIC DATA FOR SWANSEA AND TRIABUNNA

A = Precipitation (mm); B = No. of raindays (Prec. ≥ 0.25 mm);
C = Mean daily maximum temperature (°C); D = Mean daily minimum temperature (°C).

Swansea

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
A	4.1	4.8	6.3	5.8	4.2	6.4	5.0	3.5	3.8	5.5	4.7	6.3	60.4
B	9	8	10	11	10	12	12	12	12	13	11	11	131
C	21.6	21.9	20.4	17.7	15.2	12.9	12.6	13.6	15.5	17.4	19.3	20.7	
D	11.2	11.7	10.2	8.1	5.8	4.4	3.8	4.2	5.7	7.2	8.8	10.3	

Triabunna

A	4.1	5.4	7.1	6.3	4.3	7.4	5.0	4.1	3.9	6.4	4.9	7.7	66.6
B	7	6	7	9	7	9	8	9	9	11	9	9	100

procedure gave a frequency rating out of ten for each species in each sample area. The frequency figures give an index of the relative abundance of single species through the transect, but do not indicate relative dominance of species within the sample areas.

The sampling took place in August 1972 so some geophytes and annuals have almost certainly been missed. The sampling was augmented by observations elsewhere on the spit and in the saltmarsh in both August 1972 and December 1972. All plant species observed during both visits were collected and where possible identified to the species level.

RESULTS AND DISCUSSION

The levelling traverse revealed that the beach ridges and swales generally increase in height towards the lagoon (figure 2). From general observation it seems that this is the case in all but the northern part of the spit where Davies (1961) probably located his survey lines. The anomolous results reported by Davies *(loc. cit.)* for the Rheban spit seem thus to be the result of selecting for surveying an atypical cross-section of the spit. Davies *(loc. cit.)* explains the typical Tasmanian decrease of ridge and swale height towards the sea in terms of a steady lowering of sea level. However, a combination of other factors such as a general decline in constructive swell intensity or a decrease in sediment supply may produce a similar result. Local difference in ridge spacing, height and alignment can be accounted for by shorter term changes in condition in the offshore regime related to wind patterns, storm frequency, swell direction and wave size (Davies 1959).

At Rheban the different phases in beach ridge building have been separated by periods of erosion which are demonstrated by the manner in which the more recent sets of beach ridges truncate the older sets. In this context the use of linear regression as an analytical tool (Davies 1961) is inappropriate as the extent, number and dimensions of the eroded beach ridges cannot be ascertained.

Unlike most Tasmanian beach ridge systems which are eroding at their seaward margins (Davies 1957), the Rheban system has been actively advancing since at least 1946. Measurements from vertical aerial photographs taken in 1946 and 1966 and from the surveyed traverse reveal that the spit is growing seaward at a rate of approximately five m per annum. However, this rate of aggradation is confined to the southern end of the spit, while in the north the coast has been relatively stable (figure 1) and in parts the ridges are being actively undercut. This erosion is most likely due to concentrated wave attack initiated by the presence of a deeper channel (7.5 m) normal to the beach which extends 250 m to 2.5 km or more offshore. In parts of the south of the spit two high dunes have formed since 1946. The frontal dunes are both steeper and, on the whole, taller than the older beach ridges. These differences may relate to the introduction of marram grass, *Ammophila arenaria*, which has displaced *Festuca littoralis* as the sand binder on the spit, and which appears to be a more efficient performer of this function than the native grass.

The transect crossed two major soil types separated by a sharp boundary (figure 2). On the two major frontal dunes little or no pedologic development has taken place, although the soil on the more inland of these dunes exhibits some darkening of the surface layer with organic matter. These soils are classified as Uc 1.21 (Northcote 1971) and are composed of white (10YR 7/3 dry) sand with a low content of shell fragments. In the swales in the foredune complex the soils exhibit some weak mottling (5YR 5/8 wet) immediately above the watertable, which in December 1972 was located at a depth of approximately 50 cm.

A weak podzol has developed on the beach ridge system. The Northcote notation for this soil is Uc2.21. The following description characterizes the soil:

Horizon 1	0-15 cm	very dark greyish brown (10YR 3/2 moist) sand.
Horizon 2	15-23 cm	light grey (10YR 7/2 moist) sand (gradational change from horizon 1)
Horizon 3	23-200 cm+	brownish yellow (10YR 6/6 moist) sand (sharp change from horizon 2) becoming progressively yellower with depth.

The soil in the saltmarsh on the margins of the lagoon consists of peat to approximately 30 cm underlain by a gleyed sand.

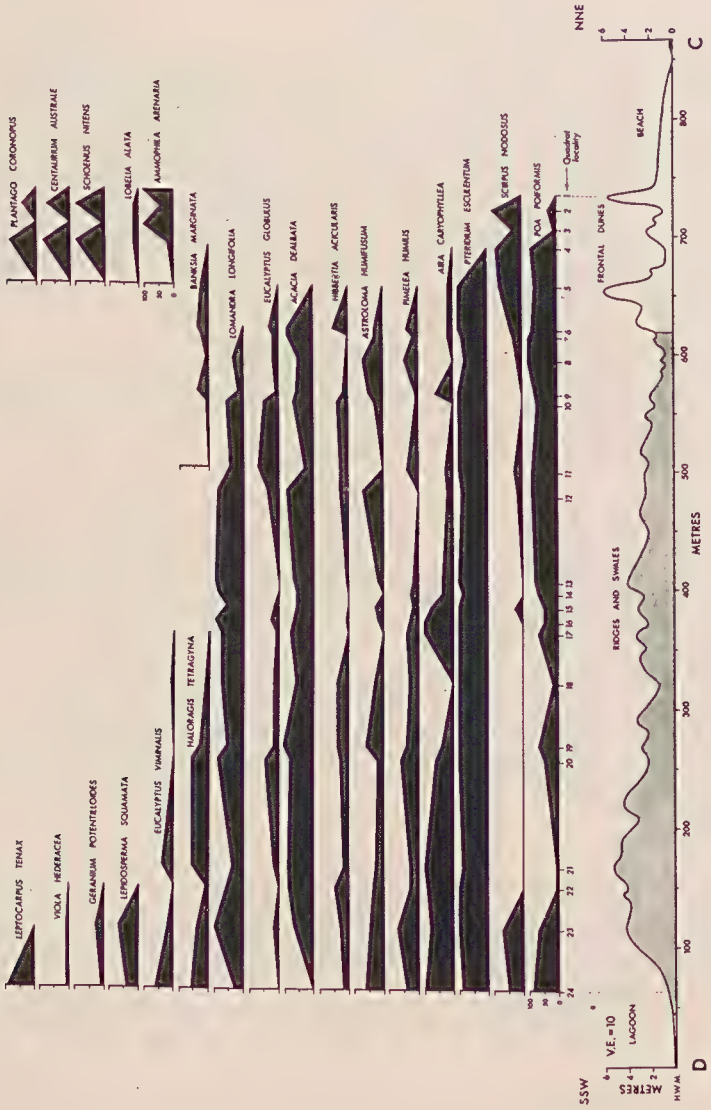

FIG. 2.- The percentage frequency of selected species through the transect.

Figure 2 shows the relative frequency of several of the more important species along the surveyed line. A list of species collected is appended along with some indication of their relative occurrence in the four main vegetation zones of the spit.

In the south of the spit the foredune is almost entirely vegetated by *Ammophila arenaria* on its crest and seaward slope (plate 1). However, *Sonchus megalocarpus* occurs sporadically among the tussocks, and on the upper part of the beach occasional individuals of *Cakile edentula* were found in December but not August. As mentioned earlier *Ammophila arenaria* appears to have almost totally displaced *Festuca littoralis* which was observed to occur quite rarely, but generally to the seaward of *Ammophila*. On the inland slope of the foredune *Ammophila* is dominant for the most part, but is suppressed in some areas where low shrubs of *Acacia longifolia* var. *sophorae* have become established. *Ammophila* maintains dominance on the second smaller frontal dune where *Acacia longifolia, Scirpus nodosus, Poa poiformis* and *Hypochaeris radicata* are also quite common.

PLATE 1.- The seaward slope of the foredune dominated by *Ammophila arenaria*. An embryonic dune can be seen in the middleground, where occasional individuals of *Cakile edentula* are also evident.

The third and largest of the frontal dunes has a contrasting vegetation, although pedologically it is similar to the first two dunes. This dune is covered with *Pteridium esculentum*, which is interspersed with tussocks of *Poa poiformis*, and quite frequently overshadowed by *Banksia marginata* (plate 3). *Ammophila*, although present on this dune, is rare.

The swales in the foredune complex are vegetated largely by a low mat of herbaceous species including *Schoenus nitens, Cotula reptans Centaurium erythraea, Samolus repens* and *Lobelia alata*. *Poa poiformis, Scirpus nodosus* and *Juncus* spp. form a slightly taller but more sparsely distributed stratum, and there is some minor colonization by *Acacia longifolia* (plate 2).

PLATE 2.- The vegetation of the frontal dunes and swales. A recent fire has killed *Acacia longifolia* in the middleground and *Banksia marginata* in the foreground.

The break in soil type from the largely undifferentiated sands of the foredune complex to the weak podzol of the beach ridge system corresponds with a dramatic change in the floristics and physiognomy of the vegetation (plate 3).

The beach ridge complex is covered by an open forest (Specht 1971) dominated by *Eucalyptus globulus*, although towards the lagoon end of the transect *E. viminalis* is equally as common.

PLATE 3.- The junction between the frontal dunes and the beach ridge system. On the frontal dune in the foreground there is a ground cover of *Pteridium esculentum* and *Poa poiformis*. Also visible are some shrubs of *Banksia marginata*. The beach ridge system in the middle and back ground supports an *Eucalyptus globulus* open-forest with a dense understory of *Acacia dealbata*.

The trees are even-aged and generally rather sparsely spaced (plate 4). Clumps of *Acacia dealbata* form a second stratum 2-3 tall over much of the beach ridge area. A third stratum generally 1 m tall is dominated by *Pteridium esculentum*, *Poa poiformis* and *Lomandra longifolia*. The fourth, least consistent stratum, is dominated by small prostrate shrubs, mainly *Astroloma humifusum* and *Hibbertia acicularis*.

Although the physiognomy of the beach ridge vegetation remained constant throughout the transect, some variation in floristic composition was evident (figure 2). Several species such as *Banksia marginata*, *Scirpus nodosus* and *Carpobrotus rossii* were common on the seaward ridges and swales but rare or absent towards the lagoon. Other species such as *Eucalyptus viminalis*, *Haloragis tetragyna* and *Lepidosperma squamata* were common towards the lagoon end of the transect but rare or absent elsewhere.

To clarify the nature of this change the beach ridge complex sample areas were ordinated on the basis of the frequency data using the polar ordination technique of Bray and Curtis (1957). The highest coefficient of distance (calculated by the formula $D = 100 - \frac{2w}{a + b}$ where w = the sum of the lower scores for each species in the two stands being compared, a = the sum of scores for one stand, and b = the sum of scores for the other stand) was found to be between the swale sample area 10 and sample area 24 (D = 75.3). This latter sample area, unlike all the others, was not situated in a swale or on a ridge, but rather was located on the lower part of the slope leading into the saltmarsh. However, its affinities proved to be more with the ridge sample areas in the lagoon end of the transect than with the swale sample areas in the same part of the transect.

PLATE 4.- Typical tree spacing on the beach ridge system. The main visible components of the flora are *E. globulus*, *A. dealbata*, *Lomandra longifolia* and *Pteridium esculentum*.

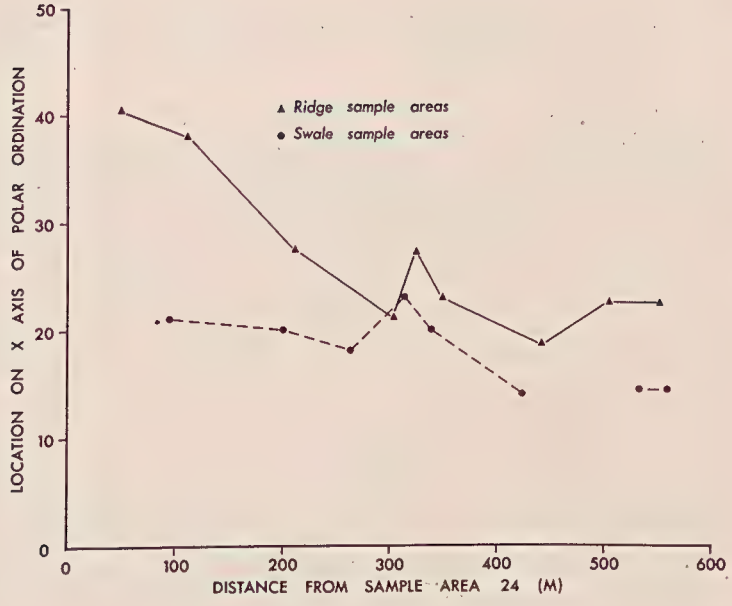

FIG. 3.- Ordination of the beach ridge system sample areas. The relationship between scores on the x axis of the polar ordination and distance from sample area 24 is shown. Sample areas 10 and 24, the poles of the x axis ordination, are omitted from the figure.

Figure 3 shows the relationship between the scores of the beach ridge system sample areas on the axis defined by sample areas 10 and 24, and distance from sample 24. This figure reveals that the vegetal variation within the beach ridge system is continuous. Interestingly, it also reveals that there is much more variation in the vegetation of the ridges than in that of the swales, and that the swale sample areas, almost without exception, have greater affinities with sample area 10 than the ridge sample areas.

The saltmarsh was not included in the transect. However, general observations revealed that several zones could be distinguished which seemed to be related to drainage and elevation. In the better-drained and higher parts of the marsh there is a dense growth of *Poa poiformis*. In these parts of the saltmarsh there is no peat development. On the most ill-drained and lowest portions of the marsh *Salicornia quinqueflora*, *Samolus repens* and *Suaeda australis* form a low succulent mat. In the imtermediate areas, which comprise most of the saltmarsh, *Juncus maritimus* is found in variable mixture with *Leptocarpus tenax* and *Gahnia trifida*, with a ground layer of the succulents.

From the previous descriptions it can be seen that there are two major vegetation zones on the spit (excluding the saltmarsh) which correspond with two distinct soil types. Although the change from one major vegetation type to the other is abrupt, as is the soil boundary, within these vegetation zones there is more or less continuous variation in vegetation. The frontal dunes can be divided into three subzones, one dominated by *Ammophila*, one dominated by low herbs, and one dominated by *Pteridium esculentum* and *Banksia marginata*. The first is essentially a colonizing community, *Ammophila* acting as a sand binder and dune builder, and tending to become less important with increasing shelter and sand stability. In 1946 the present third dune on the transect was the foredune (figure 1), and appears to have been largely covered with *Ammophila*. Since 1946 this dune has become increasingly further from the sea, with a consequent increase in shelter, and *Ammophila* although present is a minor component of the flora and mostly senescent. The ameliorated conditions have allowed the invasion of species from the beach ridge system, an invasion which is still continuing as evidenced by the presence of several sapling *Eycalyptus globulus*.

The swale community is probably related to the relatively shallow depth of the watertable, and the probability of occasional waterlogged conditions. This community has suffered the most from cattle grazing, and has the largest number of exotic species of any natural community in the study area.

The sharp break in soil and vegetation type at the junction of the frontal dunes and the beach ridge system suggests that a considerable time intervened between the formation of the most seaward and presumably youngest beach ridge and the oldest of the frontal dunes. The relative uniformity of the soils and vegetation of the beach ridge complex further suggests that the period between the formation of the youngest and oldest beach ridge was considerably less than the period between the formation of the youngest beach ridge and the oldest frontal dune. Variation in the vegetation of the beach ridge complex may partially relate to height above sealevel and its effect on available moisture in the deep permeable sands. However, there is a distinct possibility that this variation may also partially relate to subtle changes in edaphic conditions consequent upon variation in the age of the ridges.

One of the most interesting features of the vegetation of the Rheban spit is the presence of *E. globulus*. This eucalypt is only rarely found on deep siliceous sands, only two other such occurrences being known (Kirkpatrick, in preparation). The spit also presents one of the few opportunities in Tasmania to study succession on currently forming beach ridges, and is also of considerable geomorphic interest. The vegetation of the spit, although obviously deleteriously effected by grazing, is reasonably typical of beach ridge vegetation in Tasmania. Much of this type of vegetation is disappearing under the pressures of agricultural and recreational development. Thus there are strong reasons for conserving the vegetation of this area by granting it a more secure status than it enjoys at present.

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APPENDIX

Species collected from the Rheban Spit

1 = the frontal dunes (excluding the swales) 3 = the beach ridge system

2 = the swales between the frontal dunes 4 = the saltmarsh

vc = very common; c = common; o = occasional; r = rare; + = alien species

SPECIES	1	2	3	4
Dennstaedtiaceae				
Pteridium esculentum (Forst. f.) Nakai	c	-	vc	-
Gramineae				
+Aira caryophyllea L.	c	c	c	-
+Ammophila arenaria (L.) Link.	vc	o	-	-
Danthonia setacea R. Br.	o	-	c	-
Dichelachne crinita (L.f.) Hook. f.	o	-	c	-
Distichlis distichophylla (Labill.) Fassett	-	-	-	c
Festuca littoralis Labill.	o	-	-	-
+Holcus lanatus L.	-	o	-	-
Poa poiformis (Labill.) Druce	c	c	vc	c
+Sporolobus virginicus (L.) Kunth.	-	o	-	-
Stipa compacta D.K. Hughes	o	-	o	-
Cyperaceae				
Gahnia trifida Labill.	-	-	-	c
Lepidosperma squamata Labill.	-	-	o	-
Machaerina juncea (R. Br.) Koyama	-	o	-	-
Schoenus nitens (R. Br.) Poir.	-	c	-	o
S. tenuissimus Benth.	-	o	-	-
Scirpus nodosus Rottb.	c	c	o	o
Restionaceae				
Leptocarpus tenax (Labill.) R. Br.	-	-	r	c
Juncaceae				
Juncus bufonius L.	-	o	-	-
J. maritimus Lam.	-	r	-	vc
J. pallidus R. Br.	-	r	r	r
J. planifolius R. Br.	-	o	-	-
Luzula campestris (L.) DC.	-	-	o	-

Liliaceae				
Dianella revoluta R. Br.	-	-	r	-
Lomandra longifolia Labill.	-	-	vc	-
Orchidaceae				
Corybas diemenicus (Lindl.) H.M.R. Rupp	-	-	o	-
Pterostylis alata (Labill.) Reichenb. f.	-	-	o	-
Casuarinaceae				
Casuarina littoralis Salisb.	-	-	r	-
Proteaceae				
Banksia marginata Cav.	c	-	c	-
Santalaceae				
Exocarpos cupressiformis Labill.	-	-	r	-
E. strictus R. Br.	-	-	o	-
Polygonaceae				
+Rumex acetosella	o	o	o	-
Chenopodiaceae				
Salicornia quinqueflora Bunge ex Ung. - Sternb.	-	-	-	vc
Suaeda australis (R. Br.) Moq.	-	-	-	c
Ficoidaceae				
Carpobrotus rossii (Haw.) N.E. Br.	o	o	o	-
Caryophyllaceae				
Scleranthus biflorus (Forst. et Forst. f.) Hook. f.	o	-	r	-
Cruciferae				
+Cakile edentula Hook.	o	-	-	-
Rosaceae				
Acaena anserinifolia (Forst. et Forst. f.) Druce	o	o	-	-
A. ovina A. Cunn.	-	r	-	-
Mimosaceae				
Acacia dealbata Link	-	-	vc	-
A. longifolia (Andr.) Willd.	o	o	-	-
A. melanoxylon R. Br.	-	-	r	-
A. verticillata (Lher.) Willd.	-	r	-	-
Papilionaceae				
Aotus ericoides (Vent.) G. Don.	-	-	o	-
Dillwynia glaberrima Sm.	-	-	o	-
Indigofera australis Willd.	-	-	r	-

SPECIES	1	2	3	4
Kennedia prostrata R. Br.	-	-	o	-
+Lotus corniculatus L.	-	o	-	-
+Trifolium repens L.	-	o	-	-
+Ulex europaeus L.	-	o	o	-
Geraniaceae				
Geranium potentilloides Aucct., non certe Forst. f. ex Willde.	-	-	o	-
Oxalidaceae				
Oxalis corniculata L.	-	o	o	-
Euphorbiaceae				
Amperea xiphoclada (Sieb. ex Spreng.) Druce	-	-	o	-
Dilleniaceae				
Hibbertia acicularis (Labill.) F. Muell.	-	-	c	-
Violaceae				
Viola hederacea Labill.	-	-	r	-
Thymelaceae				
Pimelea humilis R. Br.	-	-	c	-
Myrtaceae				
Eucalyptus globulus Labill.	o	-	vc	-
E. viminalis Labill.	-	-	vc	-
Leptospermum scoparium Forst. et Forst. f.	-	-	r	-
Onagraceae				
Epilobium sp.	o	o	-	-
Haloragaceae				
Haloragis tetragyna (Labill.) Hook. f.	-	-	c	-
Epacridaceae				
Astroloma humifusum (Cav.) R. Br.	-	-	vc	-
Epacris impressa Labill.	-	-	o	-
Leucopogon parviflorus (Andr.) Lindl.	r	-	r	-
Primulaceae				
Samolus repens (Forst. et Forst. f.) Pers.	-	vc	-	vc
Gentianaceae				
+Centaurium erythraea Rafn.	-	c	-	-

SPECIES	1	2	3	4
Convolvulaceae				
Dichondra repens Forst. et Forst. f.	-	-	o	-
Scrophulariaceae				
Veronica calycina R. Br.	-	-	o	-
Plantaginaceae				
+Plantago coronopus L.	-	vc	-	-
Rubiaceae				
Galium sp.	-	-	r	-
Campanulaceae				
Lobelia alata Labill.	-	c	-	o
Wahlenbergia sp.	o	-	o	-
Goodeniaceae				
Selliera radicans Cav.	-	c	-	c
Compositae				
+Cirsium vulgare (Savi) Ten.	-	r	r	-
Cotula reptans (Benth.) Benth.	-	c	-	o
+Gnaphalium candidissimum Lam.	-	c	-	-
Helichrysum apiculatum (Labill.) DC.	o	-	o	-
H. dendroideum N.A. Wakefield	-	-	r	-
+Hypochaeris radicata L.	o	c	o	-
+Leontodon taraxacoides (Vill.) Merat	o	-	o	-
+Picris hieracioides L.	o	-	o	-
Sonchus megalocarpus (Hook. f.) J.M. Black	o	-	-	-

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A BIBLIOGRAPHY OF TASMANITE

WITH

AN INTRODUCTION AND ANNOTATIONS

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ABSTRACT

Since the discovery of tasmanite in 1851, scientific interest in this oil shale has shown much variation. The recent resurgence of research activity on tasmanite has been occasioned by the availability of new techniques which now permit the organic matter to be examined in considerable detail.

This paper presents a summary of the history, nature and chemistry of tasmanite, followed by a comprehensive bibliography. The survey was prompted by a recent catalogue of *Tasmanites* from the palynological viewpoint, and the lack of a similar publication on tasmanite itself. The references are given in alphabetical order, together with an abstract. Additional annotations are made, if pertinent.

INTRODUCTION

Any reader of research papers on oil shale cannot fail to notice the irregular frequency of publication in this field. It must be confessed that past research has been largely a reflection of technological interest in these rocks as a source of fuel. On the contrary, the recent upsurge in geochemical investigations has been motivated by agencies interested in the composition of traces of organic matter; the interest being directly connected with the bioassay of extra-terrestrial materials; such as the lunar rocks. Because of the extreme resistance of spores and exines to biochemical and geochemical decay, it seems likely that, if life had existed elsewhere, spore-like bodies might be found in rock samples from space sources. This speculation has stimulated research into the chemistry of particulate organic matter in terrestrial rocks, including tasmanite.

Intense interest was shown in tasmanite after its discovery, and its display at the Tasmanian Court of the International Exhibition in London in 1862. However, for nearly half a century thereafter, there was indifference to the substance, followed by renewed research in the 1910's and 1930's. Later, studies of tasmanite again became negligible but revived in the 1960's following the recognition of very rich deposits in Northern Alaska. Very comprehensive literature surveys have recently been completed on the world's oil shales (Prien 1966, Neto 1971) but there are unexpected gaps in their coverage. These lacunae arise because important papers have been published in journals which do not have recognised international circulation, and thus miss the abstracting services. As tasmanite has suffered badly in this respect, the present contribution is put forward in an attempt to make good the lack of a comprehensive bibliography on this substance. This bibliography deliberately excludes those papers dealing with *Tasmanites* from the viewpoint of the taxonomist or palynologist, as an extremely comprehensive review of such aspects has recently been published by Muir and Sargeant (1971). A few selected palynological references are given only because they contain useful information on spore chemistry or provide data which assist in an understanding of the chemistry of tasmanite itself.

To distinguish between the genus *Tasmanites* and the plural form of the rock (tasmanites), the genus is written italicised and the rock in roman type with a lower case initial letter throughout this paper.

A Bibliography of Tasmanite with an Introduction and Annotations

THE NATURE AND OCCURRENCE OF TASMANITE

The first reference to tasmanite (dysodile) was published by Milligan (1852), although it was not until twelve years later than Church (1864) attempted to describe the nature of the rock. Church's paper was followed by a profusion of descriptive contributions by various authors, the result of which was considerable uncertainty as to the origin of the material and of the disc-shaped bodies found therein. Because of the existing name 'tasmanite', the disc-like disseminules were given the generic name *Tasmanites* by Newton (1875), who agreed with Ralph (1865) that the bodies were algal of uncertain affinity. During the next century, the taxonomic history of *Tasmanites* was one of nomenclatural change mixed with several reappraisals of genus, family and order. Although there is now general agreement that the disc bodies are algal microfossils, their exact classification is still doubtful. If we regard the fossil genus as equivalent to the extant *Pachysphaera* (Wall 1962), the microfossils can be regarded as cysts of a planktonic alga belonging to the class Prasinophyceae.

As mentioned above, Muir and Sargeant (1971) have published an annotated bibliography of tasmanids in which the genus *Tasmanites* is credited with 49 species but only two species are known to occur in local high concentrations. Although *Tasmanites* is scattered geographically and over a wide range of sediments from the Ordovician through the Permian to Recent, tasmanite on any reasonable scale occurs only in Alaska and Tasmania. Both deposits are marine and their genesis appears to be in prodigious blooms of a planktonic alga which grew fairly close to the ancient coast lines. It seems that the kerogen was laid down in a quiet ecosystem of shallow bays and inlets where the alga was free to multiply.

Alaskan tasmanite occurs as contorted outcrops along the northern slopes of the Brooks Range in Northern Alaska. The rock, in general appearance, is more like a low grade torbanite, nearly black in colour, more compact than that from Tasmania and considerably richer in organic matter. This oil shale has been known for a considerable time (Stoney 1900) but, only in the last few years, has it received any attention from geologists or geochemists. The species of *Tasmanites* in the Alaskan rock is a matter of doubt. Because of the terrain and climate, any commercial exploitation seems unlikely.

The Tasmanian deposit occurs in Permian sedimentary rocks and is found as a narrow belt along the Mersey Valley from Latrobe to Kimberley, continuing linearly through Deloraine to Quamby Bluff. There is another minor deposit at Beulah with which the Latrobe tasmanite is probably associated. The geology and general nature of this tasmanite are well documented, (see Twelvetrees 1911, Reid 1924 and Kurth 1934). Sporadic attempts to recover useful products have been made since 1901-2, when the Tasmanian Shale and Oil Coy. undertook preliminary work. Various retorts and processes were exploited during the ensuing years, but none was really successful. Over a dozen organisations have attempted the commercial exploitation of the Latrobe oil shale but all activity stopped in the middle 1930's.

There have been vague reports of small low grade deposits of tasmanite in Brazil and in the Sahara area of Africa.

TASMANITE KEROGEN

The kerogen of tasmanite is composed of the walls of *Tasmanites* and the earliest work on its chemical composition was by Church (1864) who postulated that this kerogen might be a sulphur analog of retinite ($C_{40}H_{64}O_4$). Later Zetzsche, Vicari and Scharer (1931) considered that tasmanin (their name for tasmanite kerogen) was a type of sporopollenin and allocated the formula $C_{90}H_{134}O_{15}(OH)_2$, but work by Kurth (1934) at the University of Tasmania cast considerable doubt on Zetzsche's findings. Brooks and Shaw (1969) also asserted that tasmanin was allied to sporopollenin and could be considered as an oxidative polymer of carotenoids but their hypothesis cannot be regarded as satisfactory. Kjellstrom (1968) examined the cell wall by microspectroscopy and considered it to be a complex lipoid substance containing hydroxy, alkyl, and carboxylic groupings. Work by the present writer substantiates Kjellstrom's opinion, and also that of Wall

(1962), the consensus now being that tasmanin is essentially a complex carboxylic lipoid-derived polymer. Nevertheless, no structural composition can be put forward with confidence and the exact nature of tasmanite kerogen must be considered as still undefined.

Tasmanite contains a small amount of soluble organic matter and Kurth and Rogers (1938) stated that the extractives have a resin-like composition. Hoering (private communication - 1968) of the Geophysical Laboratory of the Carnegie Institution of Washington has demonstrated that Alaskan tasmanite extractives contain a normal spectrum of alkanes, whereas Tasmanian extractives have an unusual composition with only a few major components. The main hydrocarbon is a tricyclic alkyl substituted alkane ($C_{19}H_{34}$). Hoering's molecular formula corresponds to that of fichtelite, a hydrocarbon associated with retene and connected, chemistry-wise, with rosin.

Burlingame *et al.* (1969) has examined the structure of the acidic extractives from tasmanites and found a simple range of alkanoic acids between C_8 and C_{16}, peaking at n-C_{11} for Alaskan, and somewhat higher for Tasmanian, tasmanite. The extractives are unusual as there is little or no component of branched or isoprenoid acids. In addition, there are present polycyclic condensed aromatic acids and other members corresponding to alkyl benzene and to naphthalene carboxylic acids.

BIBLIOGRAPHY

The bibliography has been compiled, with two exceptions, from first hand study of the cited references. As mentioned earlier, papers dealing exclusively with the botanical, taxonomic or palynological aspects of *Tasmanites* have been omitted, likewise references to Tasmanian shales other than tasmanite. In many general articles, a casual 'single sentence' reference to tasmanite might be encountered. This type of reference has also been excluded.

The bibliography appears in this paper as a supplement. As a general rule, the verbal tense of the abstract is that which best suits the tense of the original publication.

ACKNOWLEDGEMENT

The writer acknowledges the assistance of his daughter (Hilary V. Cane) who checked some of the obscure references in the archives of the Library of the University of Tasmania.

REFERENCES

Brooks, J., and Shaw, G., 1969: Evidence of Extraterrestrial Life. Identity of Sporopollenin with the Insoluble Organic Matter present in the Orgueil and Murray Meteorites and also with some Terrestrial Microfossils. *Nature*, 223, 5207, 756.

Burlingame, A.L., Wszolek, P.C., and Simoneit, B.R., 1969: Fatty Acid Content of Tasmanites in *Advances in Organic Geochemistry*, 1968, Ed. Schenck and Havenaar, pp. 131-156. Pergamon (London).

Church, A.H., 1854: On Tasmanite: A New Mineral of Organic Origin. *Phil. Mag.*, 28, 465-470.

Kjellstrom, G., 1968: Remarks on the Chemistry and Ultrastructure of the Cell Wall of some Palaeozoic Leiospheres. *Geol. Foren. Stock. Borband.*, 90, 221-228.

Kurth, E.E., 1934: *The Oil Shales of Tasmania and New South Wales*. Thesis for D. Sc. degree of the University of Tasmania (Hobart).

Kurth, E.E. & Rogers, L.J., 1938: The Oil Shales of Australia *in Oil Shale and Cannel Coal.* pp. 193-209. *Institute of Petroleum* (London).

Milligan, J., 1852: Report on the Coal said to be found in the Don River and upon the west bank of the Tamar River in Tasmania. *Pap. Proc. R. Soc. Van Diemen's Land,* 2 (1), 90-106.

Muir, M.D., and Sargeant, W.A., 1971: An annotated Bibliography of the Tasmanaceae and related forms *from* Les Acritarches. Vol. 3 of *Microfossiles Organiques du Paleozoique.* Editions du Centre national de la researche scientifique (Paris).

Neto, C.C., 1971: Bibliografia do Xisto. pp. 531. *Instituto Brasileiro de Bibliografia* (Rio de Janeiro).

Newton, E.T., 1875: On "tasmanite" and "Australian" white coal. *Geol. Mag.,* New Ser. 2, (8). 12, 337-342.

Prien, C.H., 1966: *Literature Survey on the Fundamental Aspects of Oil Shale.* pp. 183. University of Denver (Denver).

Ralph, T.S., 1865: Observations on the microscopical characters presented by a mineral (Dysodile) from Tasmania. *Trans. and Proc. R. Soc. Vict.,* 6, 7.

Reid, A. McI., 1924: The Oil Shale Resources of Tasmania. *Miner. Resour. Tasm.,* 8, (Vol. 1), pp. 119. Government Printer (Hobart).

Stoney, G.M., 1900: Naval Explorations in Alaska. *Naval Inst. Publ.* Annapolis, pp. 105 (U.S.A.).

Twelvetrees, W.H., 1911: The Tasmanian Shale Fields of the Mersey District. *Bull. Geol. Surv. Tasm.,* 11, pp. 123. Government Printer (Hobart).

Wall, D., 1962: Evidence from Recent Plankton regarding the Biological Affinities of Tasmanites and Leiosphaeridia. *Geol. Mag.,* 99 (4), 352-362.

Zetzsche, F., Vicari, H., and Scharer, G., 1931: Palaeobotanical Study of Membranes of Spores and Pollens. *Helv. Chem. Acta.,* 14, 67-78.

Supplement

A BIBLIOGRAPHY OF TASMANITE

from 1852 to 1972

containing abstracts of papers and occasional notes

Anderson, V.C., 1922: Oil Shale - A Review for 1921. *Petroleum Times*, 7, 259-263.

A resume of world operations including a brief mention of Tasmanian deposits and their workings.

Anon., 1862: On Dysodile - A Combustible Matter from the Banks of River Mersey. *Intellectual Observer*, September, 1862, p. 144. London.

A combustible rock has been exhibited in the London Geological Museum, the same as that shown at the recent International Exhibition. The combustible matter is believed identical with the rare mineral dysodile. Mention made that the organic matter consists of brownish yellow discs which are easily separated from the matrix. Its properties and pyrolysis behaviour are discussed.

Anon., 1853: Occurrence of Tasmanite. *Proc. R. Soc. Van Diemen's Land*, 2, 2, 315.

A two line record that a sample of combustible schist (dysodile?) from the Mersey River was exhibited.

Anon., 1931: "Shale Oil in Tasmania" *in "Cyclopedia of Tasmania"*, p. 386. Service Publishing Co., Hobart.

A general review of attempts at the commercial exploitation of tasmanite. The surveys of the Tasmanian Shale Oil Co. are discussed as well as their use of the Crozier retort to produce various grades of fuel oil and road bitumen.

Archer, W., 1854: On a fine pulverulent substance, washed from the conbustible schist of the Mersey River, Tasmania. *Proc. R. Soc. Van Diemen's Land*, 2, 3, 509-511.

The organic matter of tasmanite is described. The author concludes it is a resin of "smooth flattened grains" from the leaf or bark of a tree or plant. Further samples were submitted for inspection.

Ball, L.C., 1915: Oil Shale Industry. An Introduction to a Report on the Oil Shales of Lowmead now being prepared. *Q'd Govt. Min. Jl*, 16, 608-616.

Casual mention of tasmanite in world oil shale survey.

Banks, M.R., 1962: "Permian" *in* "Geology of Tasmania". Ed. A.H. Spry & M.R. Banks. *Jl Geol. Soc. Aust.*, 9, 2, 189.

Tasmanite is stated to be found in the Quamby Group of the Permian, with the opinion expressed that it is not a facies varient of the Mersey Coal Measures. Banks has clarified the stratigraphic anomalies. The matrix is a poorly fossiliferous dark siltstone.

Brooks, J., and Shaw, G., 1969: Evidence of Extraterrestrial Life. Identity of Sporopollenin with the insoluble organic matter present in the Orgueil and Murray Meteorites and also with some Terrestrial Microfossils. *Nature*, 223, 5207, 756.

Sporopollenin is believed to be an oxidative polymer of carotenoids and carotenoid esters. The infra-red spectrum of *Tasmanites* is similar to those of Lycopod spores and of extant carotenoids. *Tasmanites punctatus* pyrochromatograms are illustrated.

Burlingame, A.L., Wszolek, P.C., and Simoneit, B.R., 1969: "Fatty Acid Content of Tasmanites" in *Advances in Organic Geo-chemistry, 1968*, ed. Schenck and Havenaar, 131-156. Pergamon (London).

The soluble acids of tasmanite are of simple composition and consist of straight chain acids between C_8 and C_{16}, peaking at n-C_{11} for Alaskan, and somewhat higher for Tasmanian oil shale. Polycyclic acids occur in both deposits and are probably condensed tricyclic systems. Tasmanite acids are peculiar in that there are little or no branched chain or isoprenoid acids.

Cane, R.F., 1939: *The Chemical Composition of Tasmanite Shale Oil.* Theses for M.Sc. degree, University of Tasmania, Hobart.

The contents of this thesis are covered in Cane (1940) and Cane (1941), which see.

_____., 1940: Studies in Tasmanite Shale Oil. *Pap. Proc. R. Soc. Tasm.*, 74, 23-32.

The properties of crude tasmanite oil and distillation fractions are given. m-Cresol has been isolated from the tar acids. The sulphur distribution over a limited boiling range shows a gradual increase and aromatic sulphur compounds were shown to occur. Alkyl thiophenes have also been detected. Higher sulphur compounds were present but not identified.

_____., 1941: The Nitrogen Bases in Tasmanite Shale Oil. *Pap. Proc. R. Soc. Tasm.*, 75, 55-62.

An investigation of the heterocyclic nitrogen bases in tasmanite oil including methods of isolation and identification. Trimethylpyridine and alkyl quinolines are present. A peculiar physiologically active nitrogen base is to be found in the higher fractions and this is possibly alkaloidal in nature.

_____., 1968: The Nature of Tasmanian Oil Shale. *Pap. Proc. R. Soc. Tasm.*, 102, 2, 65-68.

The occurrence and nature of tasmanite is discussed together with an analysis of the mineral matter. The probable nature of tasmanite is considered in relation to other oil shale kerogens. Its pyrolysis behaviour differs from other oil shales and appears to arise because of the resinous nature of the kerogen. The oil is high in sulphur and appears to contain some bioactive compounds.

Carey, S.W., and Ahmad, N., 1961: "Glacial Marine Sedimentation" *in* "Geology of the Artic". *Proc. First International Symposium in Arctic Geology.*, 2, 865-894. University of Toronto Press, Toronto.

This paper discussed the ecosystem in which tasmanite was deposited. Tasmanite must have been laid down while icebergs were still in vicinity as the sediments contain occasional erratics. Many marine fossils are to be found in the sediment, as well as pyrites, glendonites and calcareous concretions. Probably reserves are more than 30 million tons.

Carne, J.E., 1903: The Kerosene Shale Deposits of N.S.W. *Mem. Geol. Surv. N.S.W.*, 3, pp. 333. Govt. Printer, Sydney.

The author compares tasmanite with the torbanites of N.S.W. He also refers to

Tasmanites discs in parrot coal from Scotland. A special section is devoted to tasmanite itself, and a full account is presented of early investigations and reports. Elemental analyses are included. The book quotes extensively from earlier papers but does not attempt to interpret previous findings.

Church, A.H., 1864: On Tasmanite: a new mineral of organic origin. *Phil. Mag.*, 28, 465-470, and also *Geol. Mag.*, 2, 237.

The Geol. Mag. reference is an account of the tasmanite exhibit in the International Exhibition of 1863. Church states that tasmanite is not dysodile and that it is resistant to chemical attack. He gives the elemental formula as $C_{40}H_{62}O_2S$ and compares it to retinite ($C_{20}H_{31}O_2H$). In the Phil. Mag. paper, the formula is given as $C_{40}H_{64}O_2S$. The ash is mainly silica and alumina with a little ferric oxide. When heated, tasmanite fuses and yields oily and solid products. The sulphur is in organic combination and tasmanite is the first carbonaceous mineral with such a large amount of combined sulphur.

Combaz, A., 1970: Microspherules muriformes dans les roches-meres du petrole. *C.R. Acad. Paris*, 270, 2240-2243.

Electron micrographs of Tasmanian and Saharan *Tasmanites* are presented and a comparison made between them. The paper includes tasmanite in a consideration of source rocks for petroleum. The author discusses mineral composition and presents trace metal analyses. Tasmanite kerogen contains not only *Tasmanites*, but amorphous brownish organic matter associated with the "spores" as well as small spherical reticulated bodies and algal mycelia. The small granules are associated with pyrites and appear to have a bacterial origin. Excellent electron scan micrographs are presented.

Conder, H., 1902: On oil shales in Tasmania. *Australian Mining Standard*, 21, 597, No. 703

A general geological description of the Mersey Valley with mention of an oil bearing shale associated with sandstones. Tasmanite outcrops on the edge of the river but better grades are to be found in the mining shafts. The paper discusses the appearance and spore content of the rock and expresses doubt as to the profitability of working the seam. Tasmanite contains oil-bearing spores which appear to have been derived from club mosses.

David, T.W.E., 1950: (Edited and Supplemented by W.R. Browne): *The Geology of the Commonwealth of Australia*. Edward Arnold and Co., 2, p. 500-502. London.

A chapter is devoted to a discussion of Australian oil shales including tasmanite. Tasmanite is a light yellow to dark brown rock, finely laminated and fissile. Its general properties are given, together with a description of the Latrobe deposit. Tasmanite lies along a belt about 7 miles wide and 27 miles long, running from Latrobe towards Quamby. Coal and tasmanite are not found in association and tasmanite usually encloses marine fossils. It seems that the oil shale was laid down along a coastline, concurrently with the deposition of coal in the inland freshwater swamps. Reserves are of the order of 20 million tons.

Dawson, J.W., 1871: On Sporecases in Coals. *Amer. J. Sci.*, 1, 4, 246-263.

A survey of certain "spore cases" in coal and clays. Reference to *Tasmanites* found in the Devonian series at Kettle Point, Lake Huron.

Donnell, J.R., Tailleur, I.L., and Tourtelot, H.A., 1967: Alaskan Oil Shale. *Colo. Sch. Mines Qtly.*, 62, 3, 39-43.

A general review of oil shales in Alaska containing a paragraph devoted to tasmanite. The tasmanite seam is up to 5 feet thick and oil yields of up to 150 gals/tons have been recorded. The mineral matter contains diagenetic silica and barite.

Down, A.L. and Himus, G.M., 1940: The Classification of Oil Shales and Cannel Coals. *Jour. Inst. Pet.*, 26, 329-335.

A suggested classification of oil shale and torbanite based on concentration and type of organic matter. Tasmanite is classed as a spore shale within the general group "Kerogen Rocks".

Dulhunty, J.R. and Dulhunty, R., 1949: Notes on Microspore Types in Tasmanian Permian Coals. *Proc. Linn. Soc. N.S.W.*, 74, 3-4, 132-139.

Microspores in Tasmanian Permian Coal were surveyed in order to compare the Tasmanian and N.S.W. deposits. Generally the types of microspores were common to both. Only casual mention of tasmanite itself.

Dun, W.S., 1912; Marine fossils from the Tasmanite Spore Beds of the Mersey River. *Rec. Geol. Surv. Tasm.*, 1.

The paper gives results of a survey of the marine invertebrates associated with tasmanite beds. Twelve species are now identified.

Evitt, W.R., 1963: A discussion and proposals concerning fossil dinoflagellates, hystrichospheres and acritachs. *Proc. Natl. Acad. Sci. U.S.*, 49, 2, 158-164. *Ibid.*, No. 3, 298-302.

Because of the confusion about the identity of certain micro-fossils, a decision was made to place *Tasmanites* into a group termed "Acritachs".

Gould, C., 1861: Report on the Resinous Shales of the Mersey River, Tasmania. *Report of the Mines Dept.*, pp. 3. House of Assembly Paper No. 8. Legislative Council, Paper No. 8. Tasmanian Parliament, Hobart.

The report gives a brief description of the outcrops and general appearance of "dysodile". Gould believes the deposit to be marine because of the nature of the fossils therein.

There is a further reference to tasmanite at Caroline Creek in Assembly Paper No. 35 (29/10/1861) in the note "Report upon the Mersey Coalfields".

Herapath, W., 1856: Copy of analysis of "White Coal or Bituminous Sand" from Australia. *Trans. N. England Inst. Mining Engineers*, 4, 191.

This reference could not be located in Australian libraries.

Hey, M.H., 1962, (2nd ed.): *An index of mineral species and varieties arranged chemically.* Condon, Printed by order of Trustees of the British Museum.

Tasmanite is classified under the category "Hydrocarbons, Resins, etc,": Sub Group 33.10 Sulphur Bearing Resins, Sub Type 33.10.4. It is a sulphur rich resin. C, 79.3% H, 10.4% O, 4.9% S, 5.3%. Ref: Dana 1010.

Hills, C.L., 1921: Oil Shale at Quamby Bluff. *Dep. Min. Tasm, Unpubl. Rep.*

Unpublished report of general features of deposit and economic aspects.

Himus, G.W., and Rudrakanchana, S., 1941: The composition of the ash of Tasmanian spore shale. *J. Inst. Petroleum*, 27, 446-447.

Ash analyses were made to determine the likelihood of *Tasmanites* being connected with Lycopods because the *Lycopodineae* are remarkable for their high aluminium content. However, the authors state that the analyses are not suitable for the differentiation of lycopods. The amount of Al_2O_3 in the ash was 11.8%.

James, C.E., 1933: Report of Tasmanian Shale Oil Investigation Committee. *Miner. Resour. Tasm*, 8, II, pp. 214. Tas. Dept. of Mines. Government Printer. Hobart.

A detailed description of the geology, extent, nature of organic matter and analyses of the Latrobe oil shale field. A section of the report is devoted to factors affecting the retorting of shale and conditions necessary to obtain maximum oil yield. A summary of research into the refining of shale oil is also given. Data are present on the economics of utilization and recovery of various distillation fractions. Five Appendixes give further information on the sampling, analyses and distillation of oil shale. Costing information is also included, including much information on the operations of the Tasmanian Shale Oil Company.

Jennings, I.B., Noldart, A.J., and Williams, E., 1967: Geology and Mineral Resources of Tasmania. *Bull. Geol. Surv. Tasm.*, 50.

Mention of the occurrence of tasmanite and the production of oil therefrom.

Johnson, J.H., 1967: Bibliography of fossil algae, algal limestones and the geological work of algae. *Colo. Sch. Mines Qtly.*, 62, 4, 1-148.

A review of the period 1956-1965. Mention is made of the papers of Wall, Eisenack, Sommer and Van Boekel on the palynology of *Tasmanites*. Represents an extension of an earlier paper *(Colo. Sch. Mines Qtly.*, 53, No. 2, 1-84), which is a review of fossil Devonian algae. Little application to tasmanite, but contains useful auxiliary information.

Johnston, R.M., 1877: Tasmanite or Mersey "Yellow Coal". 8vo, p. 8. Hobart. Also see Science Corner "Tasmanian Weekly Mail" for 25/8/1872, which is reprinted in *Geology of Tasmania*, 1888, p. 136-140 under "Tasmanite, Dysodile or Yellow Coal".

The author sees little connection between tasmanite and coal. He notes that tasmanite burns easily, leaving a white residue retaining the original shape of the sample. The organic matter is composed of disc-shaped amber-coloured bodies "welded together like grains of meal in an oat cake. The discs resemble diminutive flattened flabby gooseberry skins rent or fractured on one side as by sporadic emission of contents."

_____., 1879: *Field Memoranda for Tasmanian Botanists*. Published August, 1874. Hobart.

A description of tasmanite sacs is given as well as some general information.

_____., 1888: *Systematic Account of the Geology of Tasmania*. 4to, pp. 408 & 131 plates. Govt. Printer, Hobart.

The occurrence, nature, and stratigraphy of the tasmanite beds are discussed including a list of fossils found therein. Johnston presents a long discussion on the likely origin of the disc shaped bodies, comparing them to the sporangia of club mosses. The Mersey deposit is marine, probably estuarine, but the organic matter has been washed down by rivers, mixed with muddy sediment and deposited in a quiet Palaeozoic sea. Johnson claimed priority as to his observations on the nature and peculiar markings of the discs.

Kjellstrom, G., 1968: Remarks on the Chemistry and Ultrastructure of the Cell Wall of some Palaezoic Leiospheres. *Geol. Foren. Stock. Borband.*, 90, 221-228.

Studies show that the cell wall is a high molecular weight organic substance with a lipoid character. Ultra thin sections of the leiospheres were examined by infrared microspectroscopy and showed to contain methylene, methyl and carboxylic groups. The essential chemistry is believed to be long chain alkanes with some carboxylic functions. The ultrastructure, as revealed by electron microscopy, shows differences between species. The walls of *Tasmanites punctatus* are penetrated by pores of various sizes in a radial arrangement.

Kurth, E.E., 1934: *The Oil Shales of Tasmania and New South Wales*. Thesis for D. Sc. degree, pp. 389. The University of Tasmania. Hobart.

A comprehensive monograph on the technological aspects of tasmanite shale, largely devoted to factors affecting the yield and the quality of oil. The examination includes the effect of particle size, time, temperature, and the presence of steam upon oil yield and composition of oil. The thesis also includes a study of the composition of tasmanite organic matter and the nitrogen and sulphur distributions in the oil. Considerable detail is presented on mass balances and thermal profiles during retorting. Consideration of refining the oil is also included.

_____., and Rogers, L.J., 1938: "The Oil Shales of Australia" *in* "Oil Shale and Cannel Coal", pp. 193-209. *Institute of Petroleum, London.*

A general review of knowledge as at 1938. Discusses the general nature of tasmanite, origin, geology, history and commercial utilization. Gives data on shale oil and analyses of the mineral matter associated with the kerogen.

MacNaughton, T., 1855: Concerning the Mersey Shale. (Together with a sample of oil presented by Dr. Lee). *Pap. Proc. R. Soc. Van Diemen's Land*, 3, 1, 187-188.

A description of the resinous discs of tasmanite, as seen under the microscope, together with a brief description of the mineral.

McKee, R.H., 1925: Shale Oil. *American Chemical Society Monograph 25*. 8vo, pp. 326. Chemical Catalog Co., New York.

Mention made of tasmanite and its mining operations. Erroneously classifies tasmanite as a torbanitic deposit.

Mansfield, H.W., 1916: Oil Shales. *J. Inst. Pet. Tech.*, 2, 162-190. Casual mention in world survey.

Milligan, J., 1852: Report on the Coal said to be found on the Don River and upon the West Bank of the Tamar River in Tasmania. *Pap. Proc. R. Soc. Van Diemen's Land*, 2, 1, 90-106.

First record of "a brown schist of a nature highly combustible: its surface is usually finely punctated - it is semi soft, sectile, fissile, flexible and slightly elastic". When burning, it gives out "a peculiar and highly diffusive odour". A general description of tasmanite and its properties are given. The structure of the rock indicates a very tranquil aqueous environment for the deposition of the spores and a continuous repetition of the occurrence of deposition. The author believes that tasmanite is a bed of coal in the process of formation.

Moore, T., 1855: On Experiments Testing the Comparative Value of the Mersey Schist and the Coals from Schouten Island and Douglas River for Gas Making Purposes.

Proc. R. Soc. Van Diemen's Land, 3, 1, 177-178.

The use of tasmanite for gas production was discussed and its possible use exemplified by experimental data on destructive distillation and gas yields. A record of a talk given to the Society on 14/6/1854.

Newton, E.T., 1875: On "Tasmanite" and Australian "White Coal". *Geol. Mag.* N.S. 2, 12, 8, 337-342.

The first paper to give any scientific detail, containing the original suggestion to name the spores *T. punctatus*. Newton believed that the peculiar discs were not algae but sporangia of lycopods which go to make up the entire organic matter of the deposit. By treating tasmanite with HCl and HF, he was able to isolate individual discs and to show they were thick walled sacs with perforated walls. The occurrence and nature of tasmanite is treated in some detail.

_____., 1876: Remarks on tasmanite or Mersey Shale. *Proc. R. Soc. Tasm.* 5, 4.

This reference appears to be the record of a verbal presentation of Newton's (1875) paper at the 14/3/76 meeting of the Society, as some portions are repeated verbatim.

Nye, P.B., and Blake, F., 1938: The Geology and Mineral Deposits of Tasmania. *Bull. Geol. Surv. Tasm.*, 44.

Brief mention on p. 103 with estimated size of deposits.

Orton, E., 1850: A Source of the Bitumenous Matter of the Black Shales of Ohio. *Proc. Amer. Assoc. Adv. Sci.*, 3, 2, 373-384.

Discussion of *Tasmanites* found in the Huron shales of Ohio. It is believed the bitumenous nature of the shale is caused by the spores. Other fossils are found in the shale beds.

Penny, P., 1855: Report on the Chemical Qualities and analysis of a Combustible Mineral substance from the Mersey River, Tasmania. *Pap. Proc. R. Soc. Van Diemen's Land*, 3, 1, 108-114.

The shale is a mixture of clay and sand together with a combustible substance allied to resin. The resins in tasmanite are much less soluble than most but burn giving off much smoke. The analysis shows ash 71.2%, sulphur 0.73%. When distilled, tasmanite yeilds an oil, a strong acid and tarry matter but does not produce much gas. An ash analysis is given.

_____., 1859: Report on the Chemical Qualities and Analysis of a Chemical Substance from Van Diemen's Land. *Trans. Phil. Soc. N.S.W., Sydney Mag. of Science and Art*, 2, 213-215.

An examination was made to determine the gas making qualities, but the author states that it may be difficult to make a satisfactory gas. Gives analyses of the organic matter. The resinous matter renders the mineral highly combustible and produces much smoke when distilled in a closed vessel. Penny states it is different from coal and cannot be considered as a bitumen because of insolubility. He concludes that it is not a good gas maker.

Radforth, N.W., and Rouse, G.E., 1956: Floral Transgressions of Major Geological Time Zones. *Trans. R. Soc. Canada*, 50, 17-26.

Discusses the time distribution of *Tasmanites* from the Devonian to Tertiary eras.

Ralph, T.S., 1865: Observations on the microscopical characters presented by a mineral (Dysodile) from Tasmania. *Trans. Proc. R. Soc. of Vic.*, 6, 7.

Paper read on 27/5/1861, but only an abstract published. The author showed that "the mineral was a kind of shale containing, besides a bitumenous substance, a large amount of algae, of a spherical form which were preserved by their being coated by a resinous substance."

Reid, A.M., 1926: The Oil Shale of Tasmania. *Pap. Proc. R. Soc. Tasm., 42-51.*

A review article, covering the history and geology of tasmanite, the article depending largely on extracts from previous papers. It contains a general description of occurrence and lists marine fossils associated with the deposit. Tasmanite kerogen consists of "the waxy covering of minute disc-shaped spore cases", the cases having been preserved by the waxy or resinous substance of the outer skin (exines), although the spores themselves have decayed. A useful summary of the physical properties of tasmanite is given. Remarks on the constancy of composition over the whole area. The quantity of shale and possible utilisation is also discussed.

_____., 1924: The Oil Shale Resources of Tasmania. *Miner. Resour. Tasm.*, 8. 1, pp. 119, Tas. Dept. of Mines. Govt. Printer, Hobart.

A review of knowledge up to 1922. A detailed account of the geography and geology of the deposit, including a description of the nature and microstructure of tasmanite kerogen as well as some chemical features. Tasmanite is a marine deposit which has been laid down in shallow seas close to the Permian coastline or in marine estuaries. Consideration is given as to the best mining methods and handling of the rock. Part III is devoted to a detailed study of the shale field containing logs of bore holes and an estimation of the amount of shale in various areas.

Selwyn, A.R.C., 1855: Coal Seams of Van Dieman's Land. *Pap. R. Soc. Van Diemen's Land*, 3, 116-141.

Casual mention of tasmanite on p. 140.

Selwyn-Brown, A., 1916: Fuel Oil from Shale. *Eng. Mag.*, 50, 913-920.

Discusses the profitability of the recovery of oil from world shales; tasmanite yields 40-60 g/ton. Quotes mining and retorting costs. The paper states that spent shale is a useful fertilizer and gives ash analyses.

Singh, T.C.N., 1932: Notes on the Fossil Spores of an Oil Shale from Tasmania. *Pap. Proc. R. Soc. Tasm.*, 66, 32-36.

A reappraisal of the nature of tasmanite spores and an amplification of doubt regarding their lycopod origin. No evidence of Newton's observation of punctation on the surface of the spore wall.

Smith, P.S., and Mertie, J.B., 1930: Mineral Resources of N.W. Alaska. *U.S. Geol. Surv. Bull.* 815, p. 344. U.S. Dept. of Interior, Washington.

The tasmanite-like rock found in North Alaska is made up of large spores. The paper contains some notes on occurrence and geology.

Sommer, F.W., and Boekel, N.M. Van, 1967: Brazilian palaeozoic Algomycetes & Tasmanaceae. *Palaeontology*, 10, 4, 640-646.

A review of the work on Brazilian *Tasmanites*. Describes the plant microfossils found in Devonian marine strata. Eleven species of *Tasmanites* have been recorded, some of which are also in the Devonian shale of east Bolivia.

Stephens, T., 1876: Remarks on Tasmanite or Dysodile. *Proc. R. Soc. Tasm.* 5, 4-5.

Verbal remarks loc cit p. 5. Stephens was the chairman of the meeting at which Newton's paper was read - see Newton (1876).

Stoney, G.M. 1900: Naval Explorations in Alaska. *Naval Inst. Publ. Annapolis, U.S.A.*, 105 p. Annapolis.

A brief description of the "wood" used by Alaskan natives as fuel, with a general description of the oil shale.

Tailleur, I.L., 1964: Rich oil shale from Northern Alaska. *U.S. Geol. Surv. Prof. Paper* 475-D. pp. D131-D133. Washington.

A general description of Alaskan tasmanite with Fischer assays on various samples. Some information is given on occurrence and locations, together with a brief history of early observations.

Thiessen, R., 1921: Origin and Composition of Certain Oil Shales. *Econ. Geol.*, 16, 289-300, and *Bull. Geol. Soc. Amer.*, 32, 72-84.

A review of U.S. Devonian shales and an attempt to correlate the results of pyrolysis with the microscopic characteristics. The paper states that all the organic matter is derived from plants, and that animal remains do not occur. Discusses some U.S. shales with particular reference to the chocolate shales of the Devonian of Illinois which were first discovered in 1866. *Tasmanites* occur freely in the Devonian shales of Lake Huron and also in Ohio. Micrographs of bodies in typical poor grade tasmanite are shown. Thiessen regards them as spores and believed that the chemical composition is largely esters of higher fatty acids.

Thureau, G., 1883: Report on the Mersey Coal Deposits. *House of Assembly, Paper No. 52, and Legislative Council Paper No. 61.* (May, 1883). Hobart.

A report on tasmanite and dysodile outcrops along the Mersey River. Paper states that tasmanite "belongs to the bitumenous schists and, so far, it does not appear to have any special value at present".

Tourtelot, H.A., Tailleur, I.L., and Donnell, J.R., 1967: Oil Yield and Chemical Composition of Shale from Alaska. *7th World Petroleum Congress (Mexico).* P.D. 14, 9, 75-80.

Tasmanite included in a description of organic rocks in N. Alaska. The paper presents oil assays, elemental and spectroscopic analyses of tasmanites from Alaska, Tasmania and Ohio. Alaskan tasmanite yields up to 144 gals/ton of oil.

Twelvetrees, W.H., 1909: Report on Shale Deposits in Tasmania. *Sec. of Mines Report for 1908.* Dept. of Mines Tas., Hobart.

An earlier and condensed version of Twelvetrees (1911), together with some assays from the Tasmanian Shale and Oil Sydndicate.

_____., 1911: The Tasmanite Shale Fields of the Mersey District. *Bull. Geol. Surv. Tasm.* 11, pp. 123. Dept. of Mines, Tasmania. Govt. Printer, Hobart.

A comprehensive report with a review of previous literature. Author discusses area, physiography, stratigraphic arrangement and geology of the deposit. Some information is provided on the physical characteristics of tasmanite and the possible origin of the "seed-like bodies" which, the author believes, may be derived from lycopods. The other consensus is that they were of algal origin associated with shallow seas of the Permian coastline. The report contains considerable data on the mining and retorting operations of the Tasmanian Shale & Oil Company, and other operators. Cost analyses are given.

_____., 1918: The Bangor Mineral District. *Bull. Geol. Surv. Tasm.*, pp. 20. Dept. of Mines, Tasmania. Hobart.

Some references are made to tasmanite as occurring in the Bangor district. The material is more of a carbonaceous shale, similar to a low grade cannel coal.

Voisey, A.H., 1938: The Upper Palaeozoic Rocks of Tasmania. *Proc. Linn. Soc. N.S.W.*, 63, 5-6, 309-333.

A description of a geological survey to compare the stratigraphy of the Kamilaroi Series in N.S.W. with corresponding deposits in Tasmania. Tasmanite is mentioned only in relation to the coal horizon of the Mersey district.

Walker, A., 1937: Investigations into the Manufacture of Asphalt from Tasmanite. *Rpt. Dept. of Mines, Tasm.* pp. 40. Hobart.

A discussion of the behaviour of tasmanite on heating and of the possibility of concentrating the organic matter by froth flotation. Tasmanite concentrate can be heated to yield a semi-liquid mass that has possibilities as a road bitumen. Heating the N.S.W. oil shales did not yield a similar resinous material but only a black residue.

Wall, D., 1962: Evidence from Recent Plankton regarding the Biological Affinities of Tasmanites (Newton, 1875) & Leiosphaeridia (Eisenack, 1958). *Geol. Mag.*, 99, 4, 353-362.

A review of existing literature on the taxonomy of *Tasmanites*, leading to the acceptance of *Tasmanites* as an alga of unknown affinity. Evidence is put forward showing the very close relationships between *Pachysphaera* and *Tasmanites*. Chemical tests shown that the wall membrane consists of a complex lipoid substance with little or no cellulose. In general features *Tasmanites* and *Pachysphaera* have close biological affinities and Wall suggests that *Pachyspaera* must be regarded as a living representation of the genus *Tasmanites*.

Wells, A.T., 1957: Geology of the Deloraine-Golden Valley Area, Tasmania. *Rec. Q. Vict. Mus. L'ton.* N.S. 8, pp. 13 & 2 maps.

A brief description of tasmanite in relation to the economic geology of the area. Oil shale originated as "a small shallow water-barred basin or estuarine deposit, separated structurally from the off-shore marine beds".

Wilson, L.R., and Skvarla, J.J., 1967: Electron Microscopy of the Wall structure of *Quisquilites* and *Tasmanites*. *Okla. Geol. Notes.* 27, 3, 54-63.

A discussion, supported by micrographs, of the relationship between *T. punctatus* and *Q. buckhornensis*.

Zetzsche, F., Vicari, H., and Scharer, G., 1931: Untersuchungen uber die Membran der Sporen und Pollen. Fossiles Sporopollenin aus dem Tasmanite und der Miskaurer Braunkohle. *Helv. Chem. Acta*, 14, 67-78.

Chemical analyses of tasmanite wall resembles those of recent spores. Tasmanite "spores" were treated with sulphuric and phosphoric acids, separated with carbon tetrachloride, then chemically treated and extracted to recover "pure" sporopollenin, which authors name "tasmanin". Tasmanin was given the formula $C_{90}H_{134}O_{15}(OH)_2$ and stated to be free from nitrogen and sulphur. Acetylation shows that tasmanin contains only two hydroxyl groups and the authors suggest that ion exchange accounts for the low hydroxyl content.

Zetzsche, F., Kalt, P., Liechi, J., & Ziegler, E., 1937: Zur Konstitution des Lycopodium Sporonins des Tasmanins und des Lange-Sporonins. *J. Prakt. Chem.*, 148, 267-286.

The paper discusses the group analysis of tasmanin in relation to the analyses of other sporopollenins. Experiments show that tasmanin is resistant to normal methods of organic analysis. Ozone oxidation of tasmanite kerogen produces a variety of dicarboxylic acids such as succinic, glutaric and adipic but no malonic acid. Oxidation with acid potassium permanganate gave no succinic acid. The tasmanin molecule appears to have three methyl groups and two hydroxyls. Research supports the earlier formula of $C_{90}H_{136}O_{17}$.

NATIONAL MUSEUM
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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

VOLUME 109

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ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT FOR THE YEAR 1974

The Council has the honour to present to members the following report on the activities of the Society during the year.

COUNCIL AND OFFICE BEARERS

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Mr G.E.A. Hale

Honorary Auditor

Mr A.M.D. Hewer

PRESIDENT

The Society was honoured when His Excellency the Governor, Sir Stanley Burbury, accepted the position of President of the Society thus following in the steps of all Governors of Tasmania since Sir Eardley Eardley-Wilmot became the first President in 1843.

His Excellency took the Chair at the Annual General Meeting.

HONORARY LIFE MEMBER

Mr W.F. Ellis was elected an Honorary Life Member in recognition of the outstanding service he has given the Society, in particular his 20 years as Honorary Secretary-Treasurer of the Northern Branch.

ANNUAL MEETING

At the Annual Meeting on 5 March, Dr June Olley retired as Vice-President, and Mr H.L. Dodson and Dr E.R. Guiler as Members of the Council. The following were elected -

Vice-President	-	Mr A.R. Neilson
Members of Council	-	Mr O.W. Reid
		Dr A.G. Wallace
Honorary Secretary	-	Mr D.R. Gregg
Honorary Treasurer	-	Mr G.E.A. Hale
Honorary Auditor	-	Mr A.M.D. Hewer

A casual vacancy on the Council resulting from the death of Mr M.H. Bennett was filled by the election of Mr A.J. Dartnall.

LECTURES

The following lectures were given in Hobart during the year -

March	"What happened in 1874?"	Dr W. Bryden.
	"Vineyards in England"	Dr D. Martin
	"Recent trends in administrative science"	Prof W.A. Townsley.
	"Meditations on Tasmanian prehistory"	Dr R.L. Vanderwal.
April	"Human evolution - a review of palaeoanthropology"	Dr A.G. Wallace, University of Tasmania.
May	"The plant ecology of the West Coast Range"	Dr J.B. Kirkpatrick, University of Tasmania.
June	"Sidelights on Tasmanian ornithology"	Mr Michael Sharland.
July	"Computer-assisted information services"	Mr T.D. Sprod, University of Tasmania.
August	"One man's food...intrinsic food hazards"	Mr M.V. Tracey, CSIRO, Sydney.
September	"A survey and census of the vegetation of Mt Wellington - a case history of survival after fire"	Dr D.A. Ratkowsky, CSIRO, Hobart.
October	"Population pressures in ancient Australia"	Prof Geoffrey Blainey, University of Melbourne.
November	"Community health - a changing pattern"	Prof I.C. Lewis, University of Tasmania.

RESOURCES OF THE SEA SYMPOSIUM

Following from a suggestion of the former President of the Society, Sir Edric Bastyan, a symposium on the "Resources of the Sea" was held at Bicheno on the weekend of 2-4 November. The attendance was disappointing with a total of only 58 including the speakers.

The symposium was opened on Saturday afternoon by His Excellency the Governor of Tasmania, Sir Stanley Burbury, President of the Society. During the remainder of the afternoon the keynote address was given by Mr A. Dunbavin Butcher, followed by addresses on "The Physical Setting" by Dr D. Rochford, "The Scenic Margin" by Dr J.G. Mosley, "Minerals from the Oceans" by Dr P.J. Cook, and "Oil from the Sea Floor" by Mr B.M. Hopkins. On Saturday evening films were shown. The main theme on Sunday morning was the living resources of the sea, the addresses being "Fisheries Management" by Mr A.J. Harrison, "Farming the Sea" by Dr T. Dix, "Utilisation of the Resources of the Sea" by Mr S.J. Thrower and Mr D. James and "The Sea and its Resources as an Ecosystem" by Dr. A.J. Gilmour.

On Sunday afternoon an excursion was made along the coast between Bicheno and Piccaninny Point. On Monday, Maria Island was visited.

The proceedings of the symposium will be published in 1975.

The Council is grateful to the many people involved in the organisation and presentation of the symposium and in particular to Mr Banks, Chairman of the organising committee.

NORTHERN BRANCH

The Northern Branch of the Society based in Launceston had a successful year with excursions as well as the monthly lectures.

March	"The limits of growth"	Mr D. Walter, the retiring Chairman.
April	"What is a natural ecosystem?"	Dr David Smith, TCAE, Newnham.
May	"Self-sufficiency for poppy alkaloids in Australia"	Mr Stephen M. King.
June	"Archaeology of convict buildings on Maria Island"	Mr Ian Brand.
July	"The valley of lost footsteps" "Organs and organ music"	Dr Peter Tyler. Mr Lindsay O'Neill.
August	"Some contemporary concepts of cancer"	Dr J. Norelle Lickiss.
September	"The use of paintings for the diagnosis of mental illness"	Dr E. Cunningham Dax.
	"The Australian League for an Undivided Ireland"	Prof P.J. O'Farrell.
	As guests of the Tasmanian Historical Research Association "Aboriginal issues of the twentieth century" In association with the National Trust and the Adult Education Board	Prof A.T. Yarwood.
October	"Investigating the development of the Tasmanian landscape in the Quaternary"	Dr E.A. Colhoun.
November	"John Glover, the English Claude?"	Mr J.A. McPhee.
December	Members' night	
	"Meetings of the Royal Society"	Mr G.H. Stancombe.
	"Some experiences of drama in Japan"	Mr H.S. Payne.
	"A house in the forest"	Mr W.F. Ellis
	"Illnesses of people famous in history: the Emperor Frederick"	Dr J.C.H. Morris.
	"Days gone by"	Mr K.E.J. Robinson.

Members attended the opening of the restored Wybalenna Chapel on Flinders Island under the leadership of Dr E.V.R. Ratcliff. Mr Dennis Hodgkinson guided members on a tour of Launceston, and Mr S.M. King lead a tour of the poppy fields near Latrobe.

PAPERS AND PROCEEDINGS

Volume 107 was published in February and Volume 108 in September. Volume 109 is in preparation.

FINANCE

Despite some difficulties being experienced in the book-keeping resulting from staffing changes, the Society's finances are in a favourable condition, but with slightly lower cash balances for the year in the two main accounts. However, it does not seem necessary to alter either the subscription or budgets for the coming year because most of the difference is due to the carry over of payments from the previous year.

The special accounts are also in a satisfactory condition but of course our investments are not matching the current inflation despite the rise in interest rates on some of them.

MEMBERSHIP

During the year the membership was 540, a decrease of 7.

The membership is made up as follows -

	Northern Branch	Total
Honorary Life Members	-	4
Life Members	9	31
Ordinary Members receiving Papers and Proceedings	90	271
Ordinary Members, not receiving Papers and Proceedings	116	209
Associate Members	20	25
	235	540

COUNCIL MEETINGS

The Council met four times during the year, Dr E.V.R. Ratcliff and Mr K.E.J. Robinson represented the Northern Branch on the Council.

REPRESENTATIVES ON OTHER BODIES

Mr M.R. Banks and Dr D. Martin represented the Society on the Trustees of the Tasmanian Museum and Art Gallery. Dr M. Hurburgh was the representative of the Society on the Trustees of the Royal Tasmanian Botanical Gardens.

ACKNOWLEDGEMENTS

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and co-operation.

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(ms. received 20.11.1974)

SEDIMENTARY AND STRUCTURAL FEATURES OF THE BELL SHALE CORRELATE (EARLY DEVONIAN), STRAHAN QUADRANGLE, WESTERN TASMANIA

by P.W. Baillie and P.R. Williams

Geological Survey of Tasmania

(with four text-figures and nine plates)

ABSTRACT

The sequence of interbedded mudstone, siltstone and very fine sandstone in the Strahan Quadrangle, correlated with the Bell Shale is at least 500 m thick. Two broad associations can be defined. The ratio of very fine sand to mud in the lower association is between 3:2 and 2:3 whereas in the upper association only occasional thin sandstone beds occur. Sedimentary structures such as lenticular bedding, symmetrical ripple marks and the lack of deep water sedimentary features suggest that deposition took place in shallow water. This is supported by palaeontological evidence. Some scouring and upward fining beds suggest that deposition from waning currents occurred sporadically within this environment.

The Bell Shale correlate has been folded during two phases. The first phase produced folds plunging between 30° and 90° NW and the second phase produced folds plunging shallowly WNW or ESE. Cleavage was developed only locally during each phase. Folds of both phases produced a primary axial surface cleavage and the second phase produced crenulation cleavage in some areas. The amplitude of folds produced during the first phase decreases towards the centre of the basin. The locus of strain during the second phase of deformation was along the Firewood Siding Fault. The existence and timing of these deformation events demonstrates the uniformity in orientation of Tabberabberan structures throughout north and western Tasmania.

INTRODUCTION

The most recent work on Eldon Group correlates is the systematic mapping by officers of the Geological Survey of Tasmania, within the Strahan 1:50000 quadrangle. This mapping has involved studies of a large basin containing correlates of the Bell Shale (fig. 1).

The Bell Shale is the uppermost formation of the Eldon Group as defined by Gill and Banks (1950) in the Zeehan area. Gill (in Banks 1962) considered the Bell Shale to be a shelf-type deposit, deposited in 'deeper, quieter waters'. Banks in Talent and Banks (1967) considered that deposition of the Bell Shale took place on a rather shallow, but deepening sea floor, in which turbidity currents were active during deposition of the lower parts of the formation. Recently Webby (1972) has advocated a 'Flysch-type' environment of deposition of the Bell Shale and its correlates. Present studies, however, suggest a shallow-water origin for the beds in the Strahan Quadrangle.

The basin of deposition of the Eldon Group in the Strahan Quadrangle has been folded during the Tabberabberan Orogeny, which is a major Devonian movement recorded throughout Tasmania. The events recorded within the Bell Shale correlate are discussed below in terms of the complexities of the Tabberabberan Orogeny and the relationship of these events to structures present elsewhere in Tasmania.

Sedimentary and Structural Features of Bell Shale Correlate, Strahan

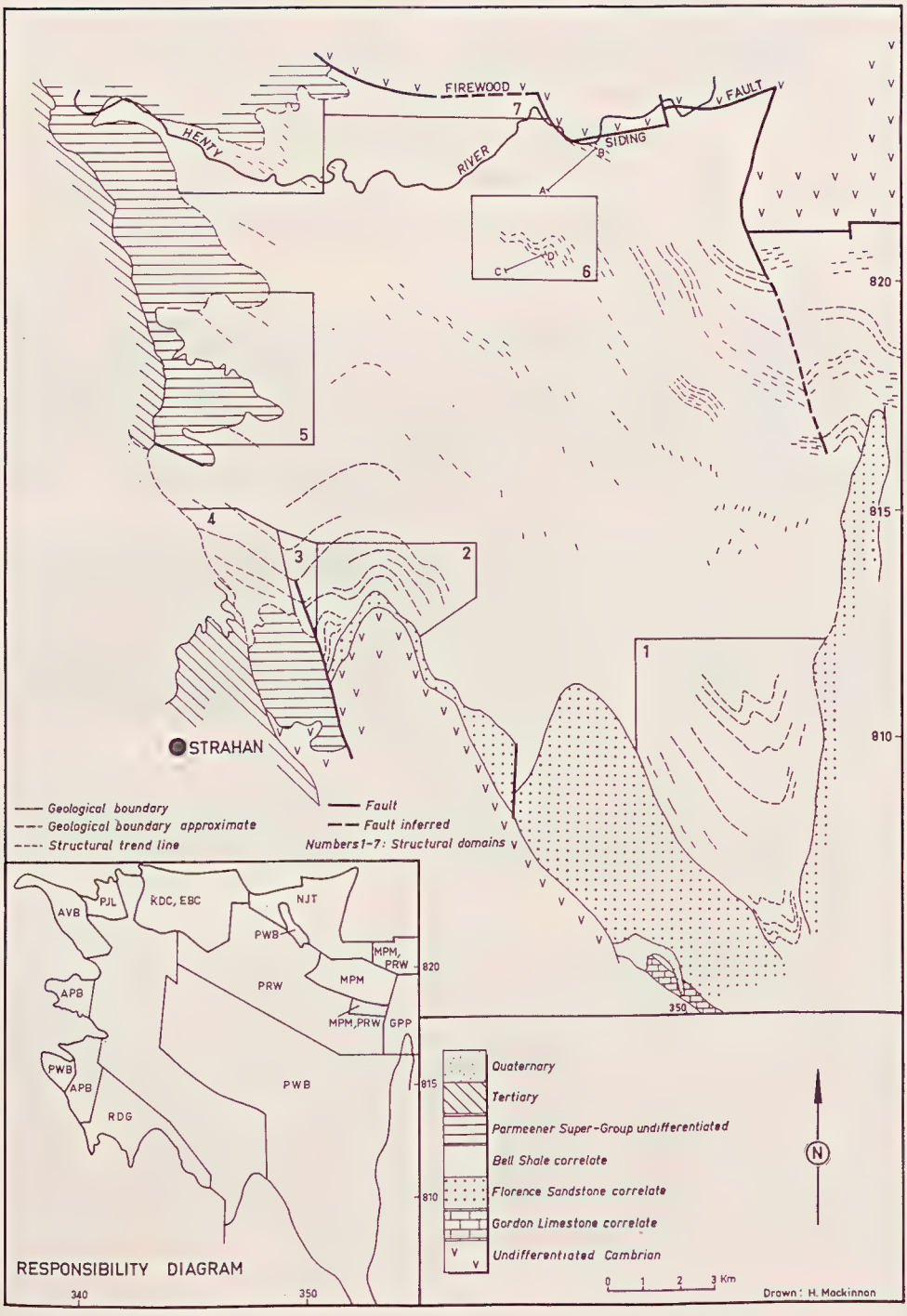

FIG. 1. - Geological Map of the Bell Shale correlate and environments. Responsibility diagram indicates areas mapped by P.W. Baillie (PWB), A.P. Bravo (APB), A.V. Brown (AVB), E.B. Corbett (EBC), K.D. Corbett (KDC), R.D. Gee (RDG), P.J. Legge (PJL), M.P. McClenaghan (MPM), G.P. Pike (GPP), N.J. Turner (NJT) and P.R. Williams (PRW).

P.W. Baillie and P.R. Williams

SEDIMENTARY GEOLOGY

General

The Bell Shale correlate in the Strahan area is a sequence of very fine sandstone and mudstone, usually deficient in sand grade material above 0.15 mm in diameter. There exists a broad twofold division with the very fine sand occurring mainly within the lower part of the sequence. Total thickness is at least 500 m.

Immediately underlying the Bell Shale correlate is the correlate of the Florence Sandstone which consists of well-bedded and well-sorted sandstone and calcareous sandstone. Towards its top, the Florence Sandstone correlate contains mudstone beds which increase in frequency and thickness towards the top of the formation. The contact between the Florence Sandstone and Bell Shale correlates is gradational over at least 25 m. In this transition zone, beds of fine sandstone up to 80 cm thick may occur, although they are generally between 10 and 20 cm thick. These sandstone layers contain more clay grade material as matrix than the underlying Florence Sandstone correlate.

In the lower part of the Bell Shale correlate the proportion of sandstone to mudstone beds is between the ratios of 3:2 and 2:3. Thickness of individual beds rarely exceeds 20 cm which are generally between 5 and 10 cm thick.

In thin section (e.g. 72-69, 74-419, 74-425; numbers refer to Department of Mines collection) the very fine sandstone is well-sorted (So 1.2-1.4) and consists of angular to subrounded quartz grains with a medium sphericity. The average diameter of the grains is 0.12 mm, but they may occasionally reach a maximum of 0.25 mm (74-425). The quartz grains are of single crystals which occasionally show undulose extinction resulting from strain. Quartz overgrowths are occasionally observed. Detrital mica is ubiquitous. Other minerals identified in decreasing order of abundance are leucoxene, well-rounded green tourmaline and zircon. The green tourmaline and the presence of some strained quartz grains indicates that a metamorphic terrain formed part of the original source area. Clay matrix constitutes 10% of the rock. The matrix often contains carbonaceous material (e.g. 72-72).

The upper part of the Bell Shale correlate is dominantly a mudstone sequence. Beds of very fine sandstone are rare and are not more than 3 cm thick and usually much less. Pyrite is common, both disseminated and as nodules. A strong tectonic cleavage is usually present.

A broad twofold division has also been recognised in the fossil assemblages of the Bell Shale correlate. M.J. Clarke (pers. comm.) reports:-
"The faunas of the Bell Shale (like those of the underlying Florence Sandstone) are benthonic and essentially indicative of shallow water conditions. Diversity is moderate, but numbers of individuals are frequently prolific. Typical forms include the brachiopods *Isorthis, Leptostrophia, Maoristrophia, Plectodonta, Chonetes, Notanoplia, Atrypa, Meristella, Nucleospira, Australocoelia, Cyrtia, Eospirifer, Howellella, Hysterolites* and the trilobites *Cheirurus, Dalmanites, Gravicalymene, Proetus, Leonaspis* and *Trimerus (Trimerus)*. Crinoid debris (and other echinoderms), prolific *Tentaculites*, michelinoceratid nautiloids, loxonemid and straparollid gastropods, bryozoans, *Pleurodictyum, Favosites*, heliolitids and *'Lindstroemia'* occur at many horizons. Bivalve molluscs, *Chondrites*, worm and molluscan burrows, together with plant debris are common only at certain localities.

As noted by Gill (1950), a wide variety of almost mutually exclusive faunules replace one another in short distances both laterally and vertically, and presumably reflect slight variations in the substrate micro-environment. Despite this variation, only two broad faunal subdivisions are evident within the Bell Shale correlate. The fauna from the lower sandstone-mudstone sequence is characterised by *Trimerus (Trimerus) zeehanensis* Gill, *Australocoelia polyspera* (Gill), and *Meristella bellensis* Gill, whereas the upper mudstone fauna is characterised by *Chonetes, Maoristrophia spp.*,

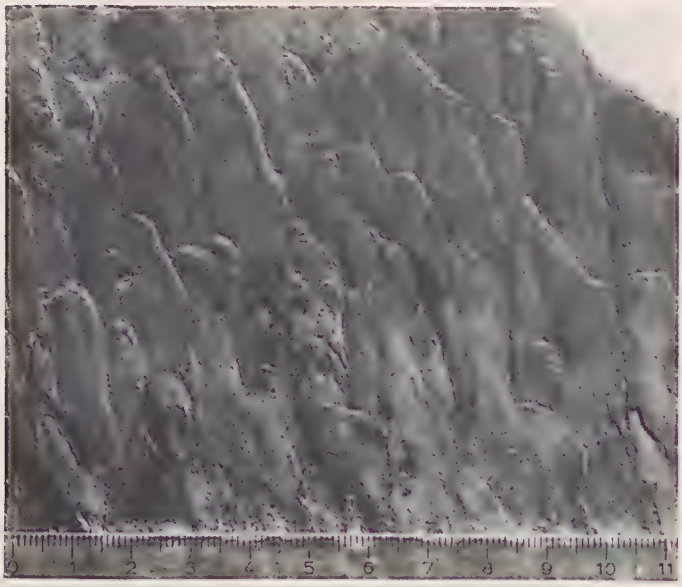

PLATE 1. - Shallow flute casts from the base of a mudstone bed.

domus, *Modiolopsis* and *Nuculites*, equally prolific *Tentaculites*, but rarer *Isorthis*, *Trimerus (Trimerus)*, crinoids and vascular plant debris".

The Modiola Phase fauna occurs in interbedded very fine sandstone (74-273) and micaceous siltstone (74-272). Specimen 74-273 is a grey-brown micaceous very fine sandstone that contains low sphericity, sub-angular to subrounded quartz grains of 0.08-0.12 mm diameter and rare heavy minerals in a clay matrix which constitutes 20% of the rock. The sandstone has an open framework but no grading is present. Specimen 74-272 is light grey in colour and contains 10% angular to subrounded quartz grains of maximum diameter 0.08 mm and abundant detrital mica in a clay matrix. The rock shows much bioturbation. In some of the very fine sandstone beds fragmented trilobites, bryozoans and thin-shelled bivalves occur in great abundance. There is no evidence to suggest that the fauna did not live

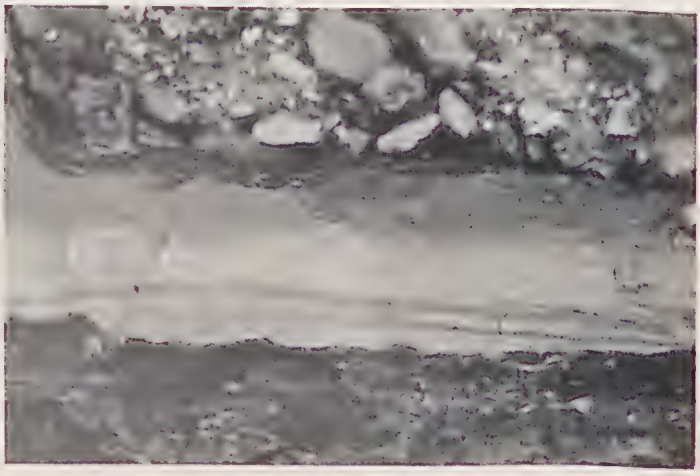

PLATE 2. - Laminated siltstone bed overlying a scoured mudstone bed. Note the grading of the siltstone unit. x 2/3.

Notanoplia pherista Gill and *Plectodonta bipartita* (Chapman). Most of the remaining fauna appears to be cosmopolitan. A similar sequence of faunas has been recognised in Victoria and elsewhere in eastern Australia in sequences of varying lithofacies (Talent 1965: in Talent and Banks 1968: Strusz 1971), so that the division appears to have real biostratigraphic significance and does not solely reflect lithological variation.

Modiola Phase faunas collected from the sandstone-mudstone sequence about 6 km NE of Strahan on the Strahan-Queenstown road are characterised by a profusion of the bivalves *Actinopteria*, *Ctenodonta*, *?Cyrtodonta*, *Glossites*, *?Grammysia*, *Lepto-*

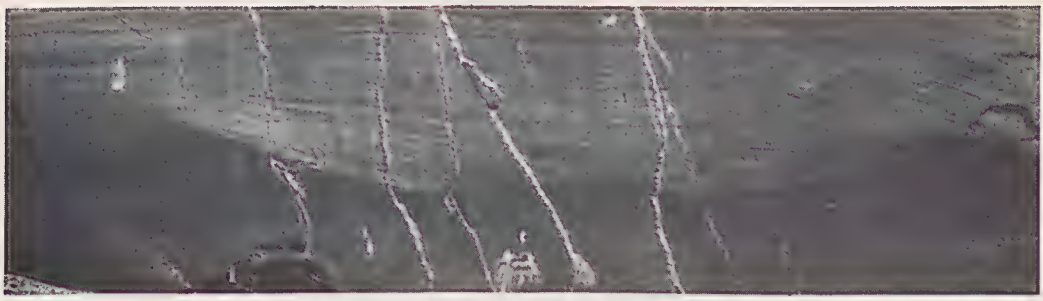

PLATE 3. - Scoured mudstone bed overlain by cross-bedded sandstone; ripple marks occur also.

PLATE 4. - Non-erosional cross-bedded unit.

All plates
natural size

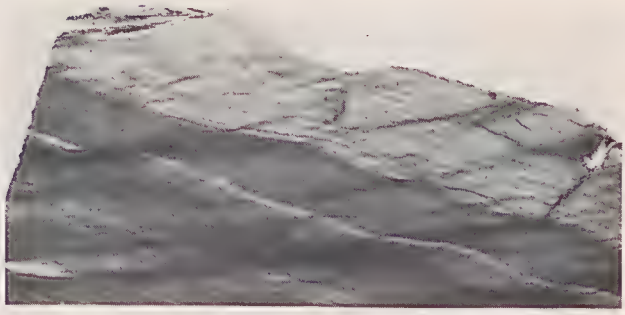

PLATE 5. - Gradational cross-bedded unit.

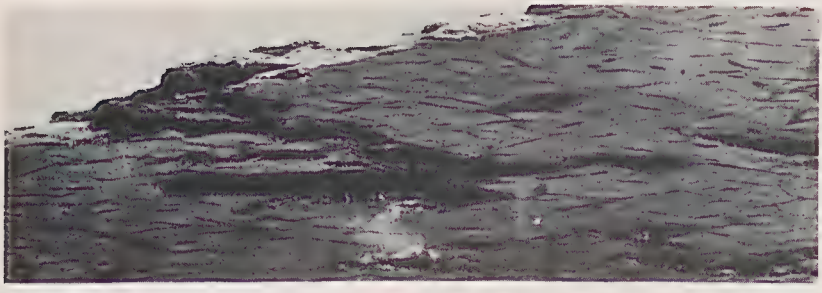

PLATE 6. - Worm burrows in very fine sandstone infilled with mud.

at the site at which they are now found buried.

Sedimentary Structures

Pre-depositional structures are largely confined to the upper mudstone sequence of the Bell Shale correlate. Shallow flute casts (plate 1) 2-3 cm long sometimes occur on the base of mudstone beds but are not obviously associated with coarser deposits. More commonly the tops of beds are scoured and have been overlain by plane laminated coarse silt which appears to grade into finer silt and mudstone (plate 2). These are not considered to be turbidites, but rather to result from deposition from waning currents. The lamination shows that initially current velocities were in the upper flow regime.

Plate 3 shows scouring of a mudstone bed by cross-bedded sand of the sandstone-mudstone sequence.

Syndepositional structures are much more common but are largely confined to the very fine sandstone layers of the sandstone-mudstone sequence. The sandstone beds very often show small scale trough bedding in sets of cross-bedded units that are generally grouped. The base of a cross-bedded unit may be erosional (plate 3), non-erosional (plate 4) or gradational (plate 5). Lithologically the cross-bedded units are generally homogenous. This type of cross-bedding is common in shallow water sequences (Conybeare and Crook 1968).

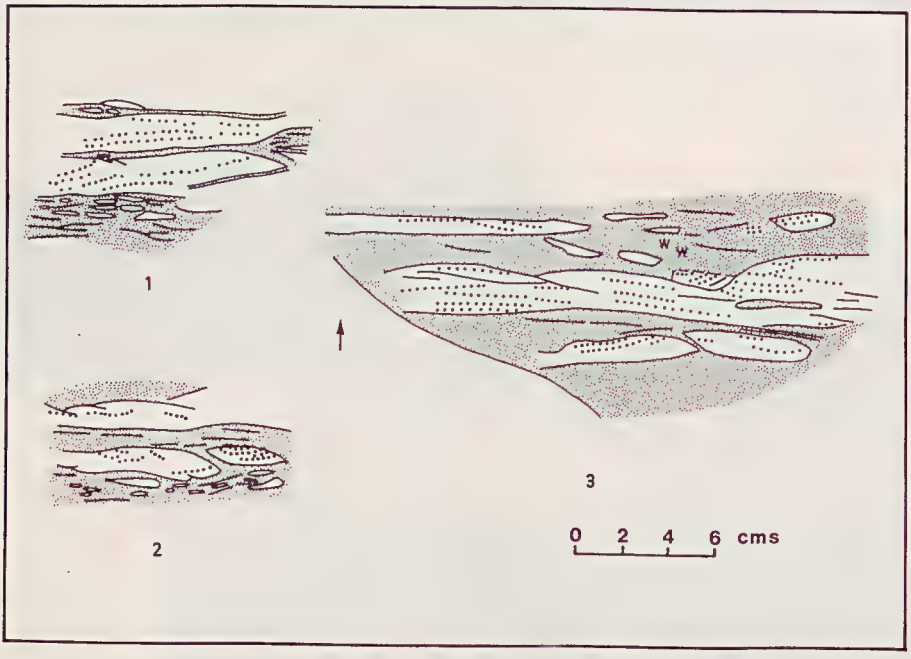

FIG. 2. - (a) Cross-bedded sandstone beds overlying lenticular sandstone bodies.
(b) Lenticular bedding, showing the cross-bedded nature of the sand units.
(c) Lenticular and continuous sand units showing cross-bedding.

Flaser or lenticular bedding also occurs in the lower part of the Bell Shale correlate (fig. 2a, 2b, 2c). Very fine-grained, often cross-stratified laminae of sand usually less than 2 cm thick are irregularly interbedded with silty mudstone.

Often the sand and silt are intimately mixed, apparently by reworking and "mottled" bedding results. This type of bedding forms in areas where a change takes place between slack and turbulent water.

Ripple marks occur on the top of sand beds in the sandstone-mudstone sequence though not commonly. They may be symmetrical (plate 2) or asymmetrical.

Post-depositional structures occasionally occur in the Bell Shale correlate. Bedding in very fine sandstone is often disturbed by the burrows of the worm *Chondrites* which have been infilled with mud (plate 6). Flame structures occur in the base of some very fine sandstone beds (plate 7) and pseudonodules occur rarely (plate 8). Soft sediment faults occur with displacement from 1 mm to 20 mm. The faults are both reverse and normal types. Bedding that has been disrupted by the formation of a tectonic cleavage also occurs (plate 9).

The bottoms and tops of the beds throughout the Bell Shale correlate are nearly always abrupt.

Summary

In summary it should be noted that whereas the term "shallow water" is open to subjective interpretation it is used here to indicate a near-shore, shelf environment. The lack of coarse sand, the large amount of detrital mica and the presence of carbonaceous material together with the limited development of a Modiola Phase fauna suggest that the Bell Shale correlate in the Strahan Quadrangle was deposited in a shallow water marine environment that was fed from a low relief distal source area. The form of depositional sedimentary structures suggests that the currents that transported material during deposition of much of the sandstone-mudstone sequence had a low velocity. Higher velocities, possibly in the upper flow regime, caused scouring and plane lamination in the upper mudstone sequence.

The presence of occasional scoured bases and the grading observed is not considered to be the result of turbidity currents but rather of waning currents.

The dominance of mudstone in the upper part of the sequence is due either to deposition in deeper water or a decrease in very fine sand grade material available from the source areas entering the basin.

Certainly the sedimentary and faunal evidence nowhere supports a "Flysch-type" environment as advocated by Webby (1972).

STRUCTURAL GEOLOGY

General

The overall structural pattern of the Bell Shale correlate is shown as trend lines and mapped fold hinges in figure 1. The trend lines are constructed from data on bedding plane orientation assuming that the folds are concentric in form.

The area has been divided into a number of domains which reflect areas mapped in sufficient detail to allow an interpretation of the structures present rather than homogeneous structural domains. They show the local variations in structural style across the basin. Domain boundaries are shown in figure 1.

The rocks in the southern part of the region show a general NNW trending fold system which folds the Bell Shale correlate together with the underlying Florence Quartzite correlate and the Cambrian System. The northern section of the basin is truncated by the Firewood Siding Fault (Blissett 1962). In the NW area of the basin the structural trend is WNW and the fold axes dip shallowly in marked contrast to the trend in the southern part of the basin. Regional mapping has also proved one major fault in the Bell Shale correlate, but the movement on it has not been established.

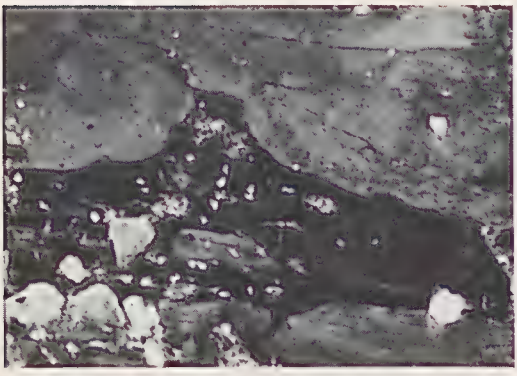

PLATE 7. - Flame structure. x 1/3.

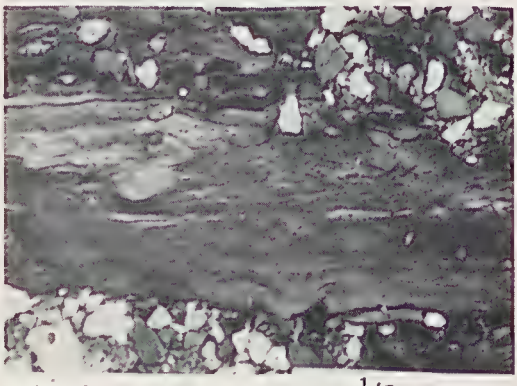

PLATE 8. - Pseudo-nodules. x 1/3.

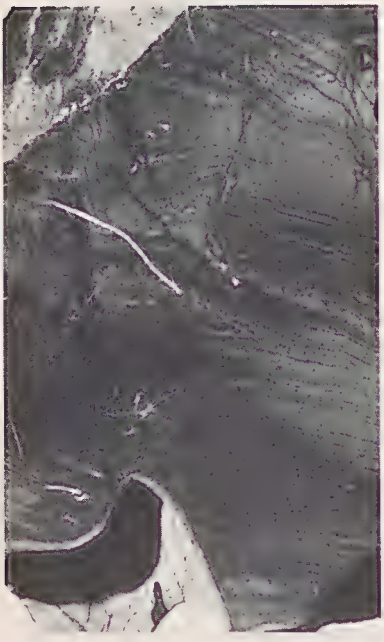

PLATE 9. - Disrupted bedding exaggerated by a tectonic cleavage. Natural size.

Description of Folding

Domain 1. The folding in this region is on a steeply plunging hinge line. Figure 2a is a contoured equal area projection of poles to bedding, showing both limbs of the fold to be steeply dipping. The small number of shallow dips in the region are probably the result of EW faulting which is common in this area and on the west coast of Tasmania in general. The plot of cleavage poles (fig. 2b), shows that the cleavage dips 80° to 068°. This is parallel to the axial surface trace of the fold (fig. 1) and as the fold is plunging at 90° (fig. 2c) the map shows a profile section. Consequently the axial surface and the cleavage directions are coincident. On the western limb of this fold cleavage and bedding become more closely parallel. A large number of the bedding values in figure 2a are from this area, accounting for the small (10°) difference between the cleavage and bedding maxima. This fold reflects the NNW folding in the underlying rocks.

Domain 2. This area comprises the anticlinal region of a NNW trending anticline-syncline structure. The plunge of the folding in this area is 34° to 334° (fig. 2d). Few cleavages have been measured in this area (fig. 2e) but those measured suggest that the cleavage is approximately parallel to the steeply dipping fold axial surface.

Domain 3. The folding in domain 3 is nearly identical in plunge and direction of plunge to that in domain 2, plunging 40° to 340°. This suggests that the folding is homogeneous across the anticlinal region of the major structure. Figure 2f shows the equal area projection for bedding poles in this domain.

Domain 4. This forms the western limb of the NNW structure in the south of the region. Equal area projections of poles to bedding and cleavage are shown in figures 2g and 2h. The trend of cleavage has swung markedly westward, now trending 300°. The bedding is much more uniform away from the folds but shows a definite trend in spreading around a hinge plunging 6° to 110°. The cleavage is not disturbed by this trend and was probably formed by folds of this trend.

Figure 2i is an equal area projection of bedding poles from immediately north of domains 2 and 3, and shows a spread in the bedding on a hinge of 30° to 320°. This emphasizes the possible significance of fold hinge rotation during later folding, as this fold is a continuation of the folds of domains 2 and 3.

Towards the north and west of the sheet the structural elements differ in orientation from those in the south. Figure 3 shows a number of equal area projections of bedding and cleavage and bedding-cleavage intersection lineations. Figure 3a shows the latter for domain 5. The fold hinges are horizontal and trend at 300°, in marked contrast to the trends in previous domains. Bedding readings from the lower reaches of the Henty River show a similar orientation of the fold hinges, 6° to 290° (fig. 3b). A larger number of readings from domain 6 shows that bedding is folded around a hinge of 15° to 150° (fig. 3c). Bedding-cleavage intersections from the same region (fig. 3d) show a plunge of fold hinges of 0° to 330° but with a considerable spread of values lying in the axial surface direction. The axial surface of this folding is dipping 80° to 060°. The cleavage in these three regions is related to the shallowly plunging folds shown on the equal area plots and is essentially parallel to the axial surfaces of these folds.

Figures 3e, 3f, 3g and 3h show the data from the Henty River close to the Firewood Siding Fault and surrounding the Fault in the Bell Shale correlate. Figure 3e from domain 7 suggests folding on a vertical hinge. The other three diagrams show folding on a vertical hinge also, and it is believed that the structural trends in these regions is related to movement along fault zones.

Minor Structures

Prior to the major folding discussed above there occurred large open bends in the

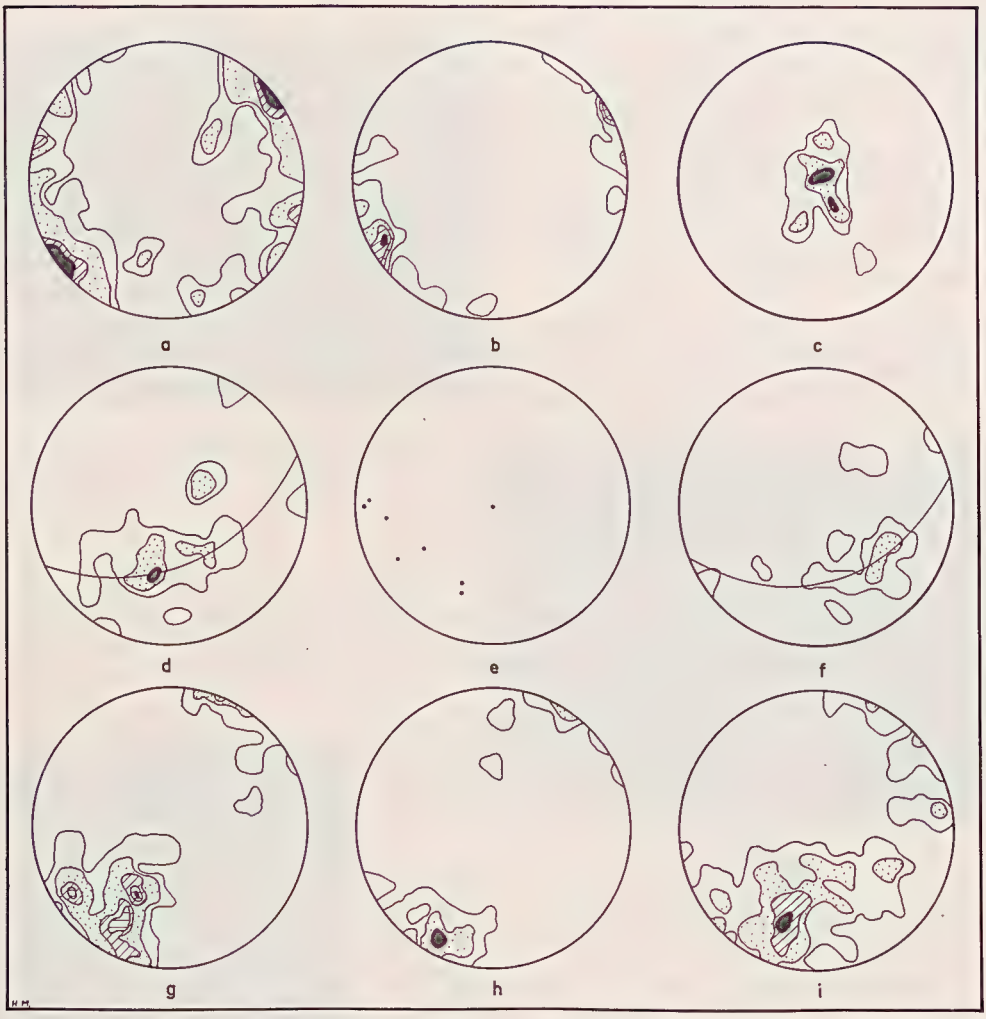

FIG. 3. - Contoured Equal Area Projections. Each point is representative of readings from a sequence of beds.

(a) Domain 1: Poles to bedding. 1, 2, 6 12% per 1% area, 13 points.
(b) Domain 1: Poles to cleavage. 2, 11, 20, 34% per 1% area, 22 points.
(c) Domain 1: Bedding-cleavage intersection lineations. 3, 9, 15% per 1% area, 17 points.
(d) Domain 2: Poles to bedding. 2, 5, 12% per 1% area, 29 points.
(e) Domain 2: Points represent poles to cleavage.
(f) Domain 3: Poles to bedding. 3, 9% per 1% area, 16 points.
(g) Domain 4: Poles to bedding. 1, 3, 8, 10, 12.5% per 1% area, 44 points.
(h) Domain 4: Poles to cleavage. 3, 12.5, 22.5% per 1% area, 20 points.
(i) North of domains 2 and 3: Poles to bedding. 0.5, 3, 6, 9% per 1% area, 96 points.

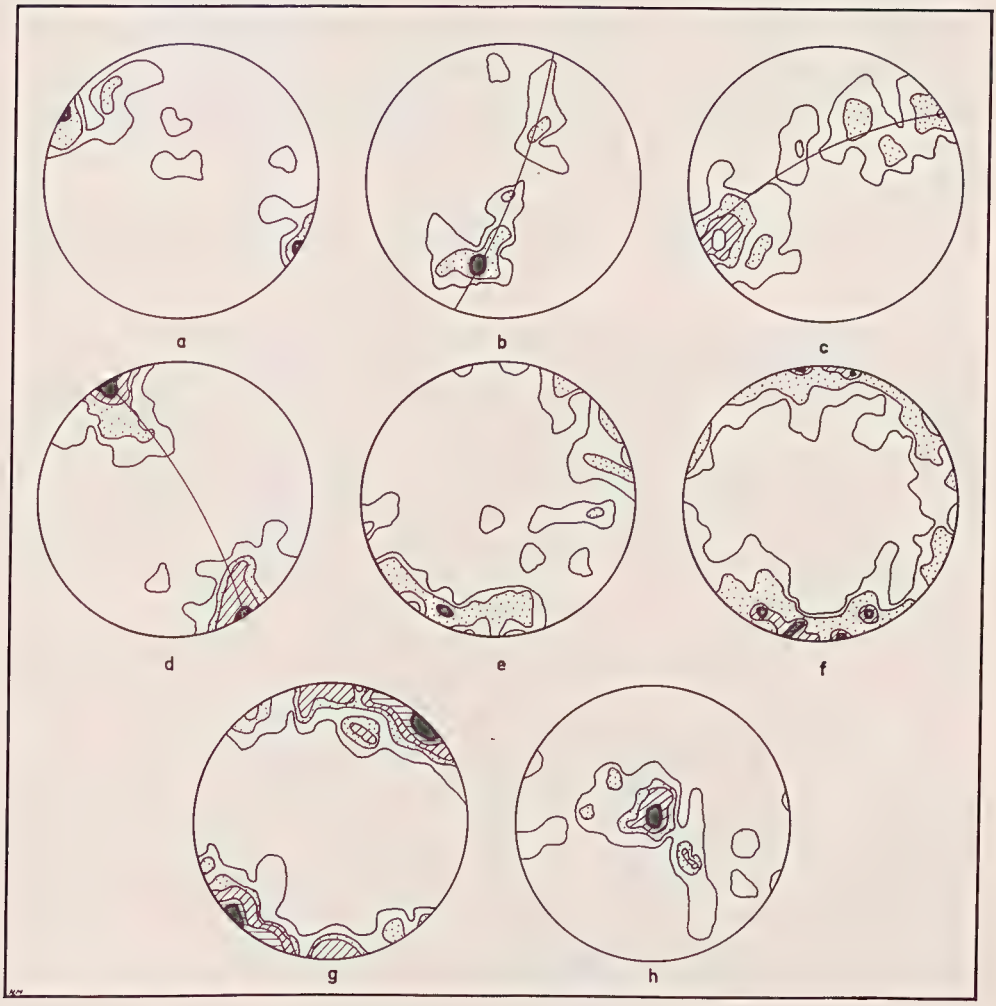

FIG. 4. - Contoured equal area projection. Each point is representative of readings from a sequence of beds.
(a) Bedding-cleavage intersections, domain 5: 3, 8, 19% per 1% area, 18 points.
(b) Bedding poles from lower Henty River: 2, 7, 15% per 1% area, 23 points.
(c) Bedding poles from domain 6: 0.5, 3, 8, 14% per 1% area, 90 points.
(d) Bedding-cleavage intersection from domain 6: 1, 4, 9% per 1% area, 38 points.
(f) Eastern edge of area, bedding poles: 0.5, 2, 6, 7% per 1% area, 111 points.
(g) Eastern edge of area, cleavage poles: 1, 2, 3, 8, 10% per 1% area, 73 points.
(h) Eastern edge of area, bedding-cleavage intersection lineations: 2, 5, 8, 14% per 1% area, 32 points.

bedding surfaces. Figure 4a shows the form of one of these warps as sketched in the field. Cleavage cross-cuts the structure. Following the major folding which caused the cleavage in the area east of the fault in the Bell Shale correlate, folding occurred which affected both bedding and cleavage (fig. 4b). This is a measured plan view of the folds. The plunge of these folds is steep and the axial surfaces strike NNE and dip steeply. Other folds which fold the cleavage occur in the Florence Quartzite correlate. In these folds the axial surface dips steeply and the plunge is WNW. A crenulation cleavage parallel to this direction was noted in the Bell Shale correlate adjacent to this area of folding. Figures 4c and 4d show the form of the shallowly plunging folds.

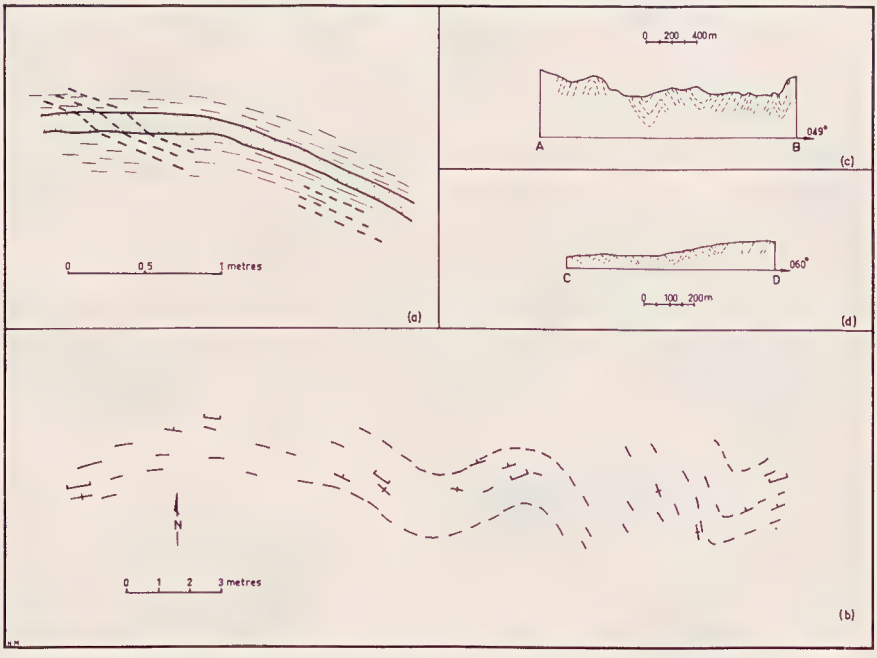

FIG. 5. - (a) Pre-cleavage fold from domain 6.
(b) Post cleavage folding - eastern edge of map.
(c) (d) Structural profiles of F2 folds. Location of sections A-B and C-D shown in fig. 1.

Microscopic Structures

Thin section examination of the morphology of the cleavage discussed above from folds on the two different trends showed that in general both sets of folds produced a primary cleavage. Pre-existing tectonic surfaces had not formed prior to the folding on either trend. The exception occurs in the regions SE from the fault in the Bell Shale correlate where the fold set trending WNW appears to have developed a crenulation cleavage. Crenulation cleavage does occur through the region but insufficient data are available to analyse its regional significance and it has been omitted from the previous descriptions.

Discussion

The best proposal to explain the data presented is that two phases of folding are developed in the Bell Shale correlate, both of which produced a primary tectonic cleavage but in separate domains. Where folding of the cleavage is observed on the

eastern edge of the area a crenulation cleavage has formed which is parallel to the more westerly trending cleavage to the west of the area. The only alternative hypothesis is that the fold axial trend swings southward away from the northern area. The evidence of crenulation cleavage, folds folding the cleavage and the suggestion of a cross-fold trend in domain 4 indicates the first hypothesis. In addition the existence of two fold trends agrees with the regional fold pattern north of the basin (Blissett 1962) and the general pattern agrees well with other regions of northern Tasmania (Williams *et al.*, in press).

Solomon (1962) named the major structure being discussed the Dubbil-Barril synclinorium and considered there to be only one phase present, a phase related to the West Coast Range Anticlinorium (*op. cit.*). He also points out that probably superimposed on this trend in the Queenstown area is a W-NNW fold trend related to the Linda Fault Zone and other E-W fractures.

The fold set observed in the south of the region plunges between 30^{o} and 90^{o} to between 330^{o} and 340^{o}. The set in the west and north of the region plunges from $+6^{o}$ to -15^{o} at between 280^{o} and 330^{o}. The two sets have not been observed to interfere in the areas which have been mapped, and consequently the age relationship between them is unclear. The folded cleavage (fig. 4b) suggests that at least locally the more northerly trend was later than the more westerly trend. However, this fold occurs in the fault-disturbed zone and has suffered body rotation during faulting; this effect can also be seen in the folds from domain 7 (see above). In the north western section of the basin there is clear evidence that the more westerly folds produced the primary cleavage and in the south of the area evidence that the northerly folds produced the primary cleavage.

It is suggested that the NW trending folds belong to the earlier phase, folding the underlying Cambrian to Siluro-Devonian rocks. These folds died out in the large area of incompetent rocks, movement being taken up by readjustment of the basin sediments by bedding plane slip and possibly faulting.

The Bell Shale correlate, which is Early Devonian in age (Banks in Spry and Banks 1962) is the uppermost unit of the Eldon Group and the Tabberabberan Orogeny occurred before the Late Middle Devonian (Balme 1960; Williams *et al.*, in press). The rocks must therefore have been close to the surface, as no evidence exists for rapid subsidence during deposition. In this situation the fold style will, in general, be more open, allowing the suggested readjustments. The plunge of these folds was, as a consequence, determined by basin irregularities and in particular the thinning of the Florence Sandstone correlate to the east.

The southern margin of the basin at this stage formed a true structural basin. The second major phase was on a WNW trend which formed a second synclinal system causing the upturning of the southern edge of the basin to form vertically plunging folds.

The intensity of the second deformation was variable, the locus of strain being along the Firewood Siding Fault zone. This zone is a continuation of major Tabberabberan structures from the Precambrian rocks at Raglan Range (Gee 1963) and through the Queenstown area. These structures are normally considered the result of the second Tabberabberan deformation phase found elsewhere in Tasmania (Williams *et al.*, in press).

Blissett (1962) has mapped structures (e.g. "Little Henty Syncline") around Zeehan and N of the Firewood Siding Fault which comprise folds trending NW and folds trending EW or ESE. Blissett (*op. cit.*) assumed that this pattern was produced by a single folding event and that the major compression was NE-SW producing NW trending folds which were warped towards the E by compression from the W.

Sedimentary and Structural Features of Bell Shale Correlate, Strahan

From the mapping at Strahan the importance of the WNW trend is emphasized as this is the major and first cleavage producing phase close to the Firewood Siding Fault. Major transport perpendicular to this direction is thus implied. From the work of Gee (1963) and that of one of the authors (P. Williams) on Mt. McCall this event is known to be the major phase of Tabberabberan movement affecting the Tyennan nucleus, and is a major phase affecting Palaeozoic rocks in NW Tasmania (Williams *et al.*, in press). In addition it gives a clear explanation for the outcrop pattern of the Eldon Group on the Zeehan Map Sheet (Blissett 1962). The authors do not see a ready explanation of this structure in a single fold phase.

The overall Tabberabberan structures can be understood in terms of a first compressional phase in a SW-NE direction followed by compression from a SSW-NNE direction. This produced refolded folds in the Zeehan area. As the locus of strain was along the Firewood Siding Fault the deformation reduced in intensity both N and S from that line, explaining the lack of interference of structure in the southern part of the area.

Thus the structure of the Bell Shale in the Strahan Quadrangle gives a much clearer insight into Tabberabberan structures in western Tasmania. The multiplicity of Tabberabberan trends and the effects of major faults on the loci of strain during folding is an important consideration in understanding Tabberabberan structure and consequently, pre-Tabberabberan structure.

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ADDITIONS TO THE LICHEN FLORA OF TASMANIA I

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(with one table)

ABSTRACT

Thirty five lichen taxa new to Tasmania are listed together with habitat information.

INTRODUCTION AND DISCUSSION

Although Wetmore (1963) records 521 lichen taxa for Tasmania the bulk of the records were made prior to 1900.

Since this time the authors have carried out an extensive survey of the major botanical regions of Tasmania covering some 700 sites at least 1 km apart which has revealed many previously unrecorded lichen species. It is the purpose of this note to record these previously unnoticed species and to provide details of habitat and distribution. The data are summarised in Table 1, together with notes on occurrences of the lichens in other states and N.Z. based on information from references indicated.

ACKNOWLEDGEMENTS

The assistance of a number of specialists particularly Mr. P.W. James and Dr. W.A. Weber for identification and confirmation is gratefully acknowledged.

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TABLE 1

NEW LICHEN RECORDS FOR TASMANIA

Lichen	No. of separate collection areas	alt. range m	Substrate	Typical Habitat	Occurrence in other States and N.Z.
Alectoria nigricans (Ach.) Nyl.	1	>900	soil & low bushes	Cradle Mt. plateau	N.S.W.[4]; N.Z.[3]
Cetraria chlorophylla (Willd.) Vain.	6	600 - 1100	soil, rock trees	*Nothofagus* forests Lake St. Clair	
Cetraria islandica (L.) Ach.	3	1050	doleritic soils	mountain moors:Tarn Shelf, Mt. Mawson	N.S.W.[4]; N.Z.[3]
Coccocarpia cronia (Tuck.) Vain.	4	100 - 500	rock	isolated rock outcrops St. Patricks Head	Q'land[4]; N.Z.[3]
Coccocarpia gayana (Mont.) Nyl.	5	60 - 600	*Melaleuca* species	rain forest Dundas	N.Z.[1]
Coccocarpia parmiliodes (Hook.) Tuck ex Curt.	2	20 - 300	mudstone	sclerophyll forest Elephant Pass	
Cornicularia aculeata (Schreb.) Ach.	4	1100	soil	mountain plateaux Mt. Eliza	
Cornicularia odontella Ach.	3	1100	soil	mountain plateaux Ben Lomond	Vic.[1]
Cystocoleus niger (Huds.) Hariot	15	3 - 1300	rock	all parts of State Orford	N.Z.[3]
Dermatocarpon hepaticum (Lam.) Th.Fr.	6	200	soil	cleared ground Bluff River	Vic.[4]; W.A.[4]; N.Z.[3]
Lecanora parmelina Zahlbr.	20	760	decaying grass	mountain moors Table Mt.	N.Z.[3]
Leprocaulon microscopicum (Vill.) Gams.	2	20	under mudstone overhangs	rocky outcrops Risdon	N.S.W.[2]
Leptogium brebissonii Mont.	2	<20	*Melaleuca* species	coastal marshes Chain of Lagoons	N.S.W.[4]; Q'land[4]; N.Z.[3]; Vic.[4]
Mastodia antarctica (Kutz.) Dodge	1	<3	rock	coastal rocks Bruny Island	

TABLE 1 (cont.)

Menegazzia aenofusca (Nyl.) Santesson	17	> 1000	dolerite	mountain summits Mt. Marion	N.S.W.[4]; Vic.[4]
Nephroma helveticum Ach.	6	200 - 1000	rock	rocky outcrops St. Patricks Head	Vic.[4]; N.Z. [3]
Normadina pulchella (Borr.) Nyl.	3	< 200	rock and other lichens	coastal rocks Temma Road.	N.S.W.[4]; Vic.[4] S.A.[4]; N.Z.[3]
Parmelia amphixantha Muell. Arg.	3	< 500	soil	open grasslands Hamilton plains	Vic.[4]; W.A.[4]
Parmelia limbata Laurer	5	20 - 300	granite	granite outcrops Cape Tourville	N.S.W.[4]; Vic.[4] Q'land[4]
Parmelia sinuosa (Sm.) Ach.	21	60 - 1100	trees	rain forest Nelson River	Q'land[4]; N.Z.[3]
Parmelia willisii (Kurok. in ed.)	1	200	loose on soil	open grasslands Ross-Lake Tooms Rd.	S.A.[1]; W.A.[1]
Parmeliella pycnophora (Nyl.) Santesson	8	60 - 1100	trees	rain forest Fossey River	N.Z.[3]
Peltigera erumpens (Tayl.) Vain.	13	300 - 1100	soil	open grassland Storeys Creek	
Peltula euploca (Ach.) Wetm.	2	< 200	rock	exposed rock Meadowbanks	Vic.[4]
Physcia ascendens (Th.Fr) Oliv. em Bitt.	9	20 - 700	trees	open forest Saltwater River	N.Z.[3]
Pilophorus conglomeratum Wilson	9	400 - 1300	rotten wood	rain forest Hartz Mts.	Vic.[4]; N.Z.[1]
Placynthium nigrum (Huds.) Gray	2	< 300	limestone	cleared grasslands Collinsvale	N.Z.[3]
Polychidium umhausensis (Auersw.) Henss.	16	200 - 1300	other lichens trees	rain forest Styx valley	Vic.[1]
Stereocaulon caespitosum Redgr.	23	800 - 1700	rock	mountain summits Mt. Mawson	N.S.W.[4]
Stereocaulon corticatulum Nyl.	34	100 - 1550	rock	mountain summits Table Mt.	Vic.[4]; N.Z.[3]

TABLE 1 (cont.)

Lichen	No. of separate collection areas	alt. range m	Substrate	Typical Habitat	Occurrence in other States and N.Z.
Stereocaulon kilmandscharoense Stein.	10	800 - 1500	rock	exposed rock outcrops Mt. Victoria	
Toninia bullata (Mey & Flot.)	2	1100 - 1300	rock	mountain plateaux Lake Augusta	N.S.W.[4]; Vic.[4]; N.Z.[3]
Usnea maculata Stirt	5	400 - 700	granite	granite outcrops Mt. Amos	
Usnea rubsescens Stirt	16	3 - 800	*Acacia* sp.	open forest St. Columbia Falls	N.Z.[3]
Usnea rubescens v. *rubrocincta* (Stirt.) Mat.	1	20	granite	granite outcrops Coles Bay	

1. Bratt, G.C., 1971: personal collection.
2. Dahl, E., *pers. comm.*
3. Martin, W., 1966.
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HETERIAS PETRENSIS, A NEW SPECIES OF FRESHWATER ISOPOD FROM TASMANIA (FAMILY JANIRIDAE, TRIBE ASELLOTA)

by P.C. Roberts

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(with one table and eight text-figures)

ABSTRACT

A new species of freshwater isopod, *Heterias petrensis* (Family Janiridae, tribe Asellota) is described. The species is found in Lake Crescent, Tasmania. A revised description is given of the genus *Heterias*.

INTRODUCTION

Although the isopod family, Janiridae, contains a predominance of entirely marine genera, freshwater genera have been described from South Africa (Barnard 1927, 1955; Grindley 1963), South America (Muller 1892) and the Bassian regions of south-eastern Australia (Sayce 1900, Chappuis 1951).

Sayce (1900) described a collection of blind janirids (*Janirella pusilla*) from a freshwater pool at Thorpdale, Gippsland, Victoria. The generic name *Janirella* was however unavailable, since Bonnier (1896) had used it previously to describe a new species of marine asellid and Richardson (1904), recognizing this, proposed *Heterias* as a replacement.

Chappuis (1951) described a blind janirid similar to *Heterias pusilla*, collected from the Guide River in northern Tasmania. These animals he designated *Pseudasellus nichollsi*, a new species and genus, apparently overlooking Sayce's (1900) description of *Janirella*. Williams (1968) suggested that *Pseudasellus nichollsi* may be congeneric or conspecific with *Heterias pusilla*.

The genus *Protojanira* was described from South Africa by Barnard (1927). He described the species *Protojanira prenticei* in 1927 and *Protojanira perbrincki* in 1955. Grindley (1963) described *Protojanira leleupi* from South Africa and discussed the main characters of the genus. All three species are blind freshwater janirids from pools in caves. Wolff (1962) placed a freshwater janirid from Brazil, *Janiropsis exul* (Muller 1892) in the genus *Heterias* because of its close resemblance to *Heterias pusilla* (Sayce 1900). Hutchinson (1967) noted the similarity between *Protojanira* from South Africa and *Heterias* from Victoria.

HETERIAS Richardson, 1904

The head bears a slight convexity suggestive of a rostral process; eyes present or absent; body oblong ovate; antennules consist of a three-jointed protopodite and a three-jointed flagellum; antennae either of greater length than the body or just less; a squama is present on the third segment of the antennae; pereonites 1-7 with smooth, rounded, setaceous lateral margins; coxae invisible from above; pereopods are all ambulatory and similar in both sexes; dactyli of peropods are bi-unguiculate, terminating in a long simple unguis, near which is a smaller lateral one; uropoda are well developed, cylindriform, biramous and shorter than the pleotelson; the first male pleopod is elongate and only slightly dilated at the base; the second male pleopod bears a thread-like endopodite, which is spiral and much longer than the peduncle;

pleopods III and IV are biramous and similar in both sexes; pleopod V is uniramous and similar in both sexes; the pleon is composed of two segments, the first narrow and inconspicuous, the second large and shield shaped.

HETERIAS PETRENSIS n. sp.

Type Material

Holotype: mature male; lodged in Australian Museum, Sydney, No. P20097.

Allotype: mature female; lodged in Australian Museum; No. 20098.

Paratypes: 15 mature males; lodged in Australian Museum; No. 20099.
15 mature females; lodged in Australian Museum; No. 20100.
15 juveniles; lodged in Australian Museum; No. 20101.
15 mature males; lodged in Tasmanian Museum and Art Gallery, Hobart; No. G1574.
15 mature females; lodged in Tasmanian Museum and Art Galley; No. G1572.
15 juveniles; lodged in Tasmanian Museum and Art Gallery; No. G1573.

All specimens collected in Lake Crescent, Tasmania, by P.C. Roberts on 30.5.1972.

General Characters of the Species

The female is larger than the male, being widest at its sixth thoracic segment (pereonite). The male is widest at its seventh thoracic segment. In most other respects, the male and female are similar, except in the morphology of the pleopods. The pereonites have smooth round lateral margins, which overhang the pereopods. The eyes are situated on the dorso-lateral margin of the head. The antennules are much shorter than the antennae and consist of a three-jointed protopodite and a flagellum composed of three segments. The antennae are longer than the body and are composed of a six-jointed protopodite and a multiarticulate flagellum. A scale-like exopodite (squama) is present on the third segment of the protopodite which bears three apical setae. The outer lobe of the first maxillae bears 10-12 pectinated setae at its distal margin. The two outer lobes of the second maxillae bear a distal row of four finely pectinated setae. The apical dentary process of the mandibles comprises in the male, on the left, one lobe of six teeth, and on the right, one lobe of six teeth plus a lacinia mobilis of six teeth. The female bears on the left, one lobe of five teeth, and on the right one lobe of five teeth plus a lacinia mobilis of five teeth. The maxillipeds are of the normal janirid structure. The pereopods are composed of seven joints, are all ambulatory and are similar in both sexes. All dactyli are bi-unguiculate. The uropods are well developed, cylindrical, attached termolaterally to the pleotelson and composed of three parts, protopodite, exopodite and endopodite. The exopodite of the uropod is shorter than the endopodite but longer than the protopodite. The pleopods are normally developed, the base of the sympode of the first male pleopod is slightly dilated at the base.

Descriptive Notes

The size ranges (rostral projection to end of pleotelson) are for males, 1.58 to 3.67 mm, and for females, 1.58 to 4.02 mm. The average length of males varied from 2.18 mm in February to 2.74 mm in September, whereas the average length of females varied from 2.30 mm in February to 2.89 in September. According to Chappuis (1951) the length of an adult male, *Pseudaselius nicholsi*, was 1.5 mm, whereas the adult female was 7 mm. Since type material of *P. nicholsi* was unobtainable, it is possible that the length of 7 mm for the female is a typographical error, since the measurement of 7 mm is several times greater than that of other heteriads.

The following descriptive notes of *Heterias petrensis* are of mature males, but they are also applicable to a mature female, except where otherwise stated.

The adult male has the same general appearance as the adult female. The body is oblong-ovate and dorsoventrally compressed. It consists of differentiated segments, with the segments arranged into three obvious groups; head, thorax (pereon) and abdomen (pleon or pleotelson) (fig. 1).

The greatest width of the male is across pereonite seven, whereas the female is widest across pereonite six. *H. petrensis* is pigmented and mottled brown in colour. Pigment is often lacking from the distal extremities of the antennae, antennules, pereopods and uropods and the ventral side of the body.

Head: The antero-dorsal edge of the head is not straight but has a slight convexity suggestive of a rostral process (fig. 1). The anterior part of the head bears two paired appendages: antennules (first antennae) and antennae (second antennae).

(a) Eyes: The sessile eyes are slightly raised above the level of the head and are situated on the dorso-lateral margins of the head. They are composed of many ommatidia.

(b) Antennules (Figure 2a): The antennules are much shorter than the antennae or the head and consist of a three-jointed protopodite and a flagellum composed of three joints. The basal joint of the protopodite is very stout, being at least twice as long and twice as wide as the second joint. The second joint is twice as wide and slightly longer than the remaining joints of the antennule, which are oblong in shape. The antennule bears simple setae and several plumose setae on its apical and lateral margins.

(c) Antennae (Figure 2b): The antennae are longer than the body. The antenna length to body length ratios are 1.2:1.0 for both males and females. The base of the antenna is composed of 6 segments of differing lengths. The first three segments are sub-quadrate and are approximately equal in size. The third segment is the longest and widest of these three segments and a scale-like exopodite (squama) is present on its outer margin bearing three apical setae. The fourth segment is half the length of the third segment and not as wide. The fifth segment is longer than the first three segments combined and is not as wide as the fourth segment. The sixth segment is the longest and narrowest segment of the base of the antennae. The segments composing the flagellum are rectangular.

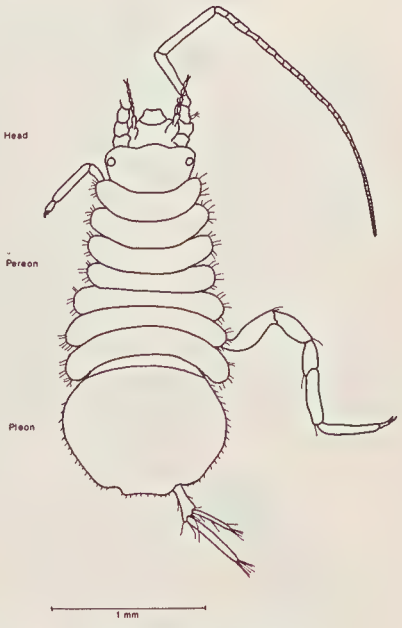

FIG. 1. - *Heterias petrensis* - dorsal view, male.

The number of segments composing the flagellum varies according to body length. In a sample of twenty three males, the number of segments of the antenna varied from 20 to 47 with a mean of 38.13± 7.08 and for females it varied from 27 to 45 with a mean of 35.3± 5.38. The antennae bear simple setae on their lateral margins and a single seta on their apex.

Mouthparts: The mouthparts are situated sub-terminally on the ventral side of the head and consist of a pair of mandibles, two pairs of maxillae, a pair of maxillipeds and an unpaired upper and lower lip. Except for minor differences the mouthparts are identical on each side and there is very little difference between the sexes, except in the mandibles.

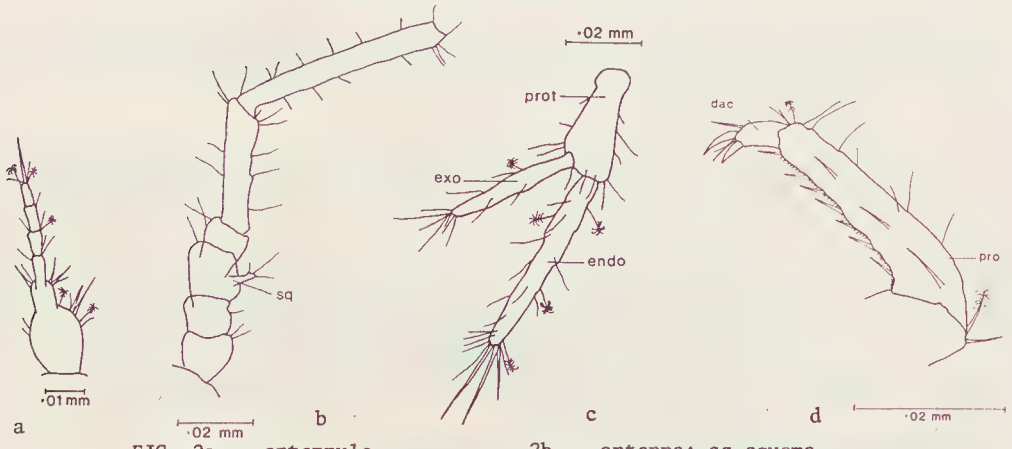

FIG. 2a. - antennule. 2b. - antenna; sq-squama.
2c. - uropod; prot-protopodite, exo-exopodite, endo-endopodite.
2d. - pereopod; dac-dactylus, pro-propodite.

(a) Mandibles (Figure 3): The mandibles are situated laterally to the oral opening and consist of a three-jointed palp, molar process, mandibular body, apical dentary process and on the right mandible only, a lacinia mobilis. The first joint of the palp is oblong in shape, and is widest at its apical end. The second joint is wider and longer than the first joint and bears seven doubly-pectinated setae on its internal margin; the second and seventh setae are twice the length of the others. The third joint of the palp is of similar length to the first joint and is slightly bent backwards towards the base with the end rounded and bearing on its medial margin 18 doubly-pectinated setae which decrease in length distally. The molar process has parallel sides and is well developed with a truncated, ridged, apex. The mandibular body bears a row of thirteen setae at its apical margin, of which the first three are pectinated and the remaining ten simple. The apical dentary process comprises in the male, on the left, one lobe of six teeth, and on the right one lobe of six teeth plus a lacinia mobilis of six teeth. The female bears on the left, one lobe of five teeth and on the right one lobe of five teeth plus a lacinia mobilis of five teeth. The hinge line of the mandibles is straight without any further special articulating surfaces.

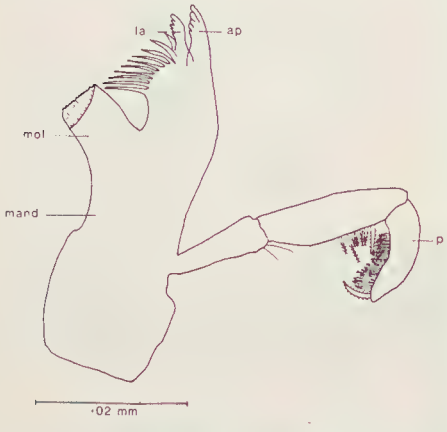

FIG. 3. - mandible - right, female; ap-apical dentary process, la-lacinia mobilis, mol-molar process, mand-mandibular body, p-palp.

(b) Maxilla I (Figure 4b): The first maxillae are each composed of two lobes, the inner lobe is slightly shorter than the outer lobe and bears about its distal margin a large number of simple setae. The outer lobe bears ten to twelve stout pectinated setae at its distal extremity. Both lobes bear setae on their anterior and posterior margins.

(c) Maxilla II (Figure 4a): The second maxillae are each composed of three lobes, one inner and two outer lobes, all three lobes arising from a common base. The inner lobe is densely covered with simple setae on its distal and posterior margins and also bears a single plumose seta amongst the simple setae on its distal margin. The two outer lobes are slightly narrower than the inner lobe and each bears a distal row of four finely-pectinated setae, and several simple setae on their posterior margin. According to Birstein (1964), "in all probability the outer lobes of the first and second maxillae correspond to the exopodites and the inner lobes to the outgrowths of the protopodites, while the endopodites are absent".

(d) Maxillipeds (Figure 4c): The maxillipeds are fused to each other at their base and cover all the mouthparts from below. Each maxilliped is composed of four parts; base (coxa), body (masticatory lobe), five-jointed palp and epipodite.

The base consists of two segments, coxa and precoxa. The coxa is small and triangular (fig. 4c), beside which is the precoxa (fig. 4c). The masticatory lobe bears two teeth on its inner distal margin and many simple setae on its distal margin. The palp is composed of five joints, differing in length and width. The first joint is a third as long as the second and the same width as the base of the second joint. The second joint is long and twice as broad at its distal end. The third joint is shorter and narrower than the second joint. The fourth joint is long and narrow, being slightly longer than the second joint and half the width of the distal end of the second joint. The fifth joint is approximately half the length and half the width of the fourth joint. All five joints have setaceous margins and the fifth joint bears a tuft of setae on its apical margin. The majority of these setae are much stouter than those on the masticatory lobe. The epipodite is large, well-developed, irregularly ovate and attached to the base of the coxa. In the male the outer edge is concave, whereas it is straight in the female.

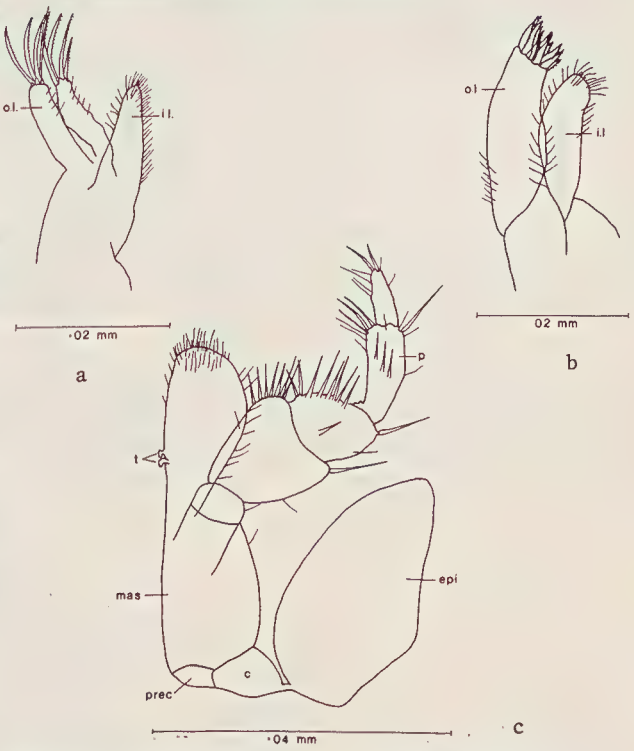

FIG. 4a. - maxilla II; o.l. - outer lobe, i.l. - inner lobe.
4b. - maxilla I; o.l. - outer lobe, i.l. inner lobe.
4c. - maxilliped - female; p-palp, t-teeth, mas-masticatory lobe, prec-precoxa, c-coxa, epi-epipodite.

(e) Upper Lip: The upper lip bearing a row of setae at its distal end is evenly rounded and divided by a transverse line which runs from margin to margin.

(f) Lower Lip: The lower lip bearing setae in tufts on its distal margins is divided longitudinally into 2 lobes by a narrow triangular slit.

Pereon: The pereon consists of seven movable segments (pereonites). The pereonites are of approximately equal length but increase in width towards the pleotelson. In the male the seventh pereonite is the widest, whereas in the female the sixth pereonite is the widest, the seventh pereonite being of approximately the same width as the fifth. The pereonites have smooth lateral margins bearing several simple setae, and overhang the pereopods. Each pereonite bears a pair of pereopods.

(a) Pereopods: The pereopods are composed of 7 joints, all ambulatory and similar to each other in both sexes. They differ only in the length of their joints, and they increase in length posteriorly.

The dactylus (fig. 2d) is crescent-shaped, long and thin, and about one quarter the length of the propodite. All the dactyli are bi-unguiculate, terminating in a long

simple unguis and on the inner margin, at its base is a smaller lateral unguis. The carpopodite is of the same length as the propodite but slightly wider. The meropodite is triangular and widest at its distal end, being just wider than the carpopodite and about half the length of the carpopodite. The ischiopodite is about the same length as the carpopodite, is widened medially and is of the same width as the meropodite. The basipodite is widened medially and is the same width as the ischiopodite but of greater length. The coxopodites are very small and fused along their basal margin to the lateral edge of the sternite of the thoracic segment. Sayce (1900) depicted the coxopodites as distinct entities, whereas Chappuis (1951) failed to mention them. All the pereopods are setaceous, bearing strong two-pointed setae on their internal margin plus very short fine setae and long fine setae on their outer margin. Plumose setae are present on the distal angle of the propodite and the carpopodite and the centre of the basipodite in the male; whereas, the female bears plumose setae only on the propodite and the carpopodite. Ovigerous females bear oostegites on the coxopodites of the first four pereonites, which together construct the brood pouch. The first two are small and ovate, the third is twice their size and the fourth is slightly smaller than the third. The oostegites do not overlap.

Pleon: The pleon consists of two somites, the first is narrow and inconspicuous, whilst the second is shield shaped and large. The pleon bears six pairs of limbs - five pairs of pleopods and a pair of uropods. In the female, the first pair of pleopods is absent. As yet is has not been possible to associate the limbs with the appropriate somite.

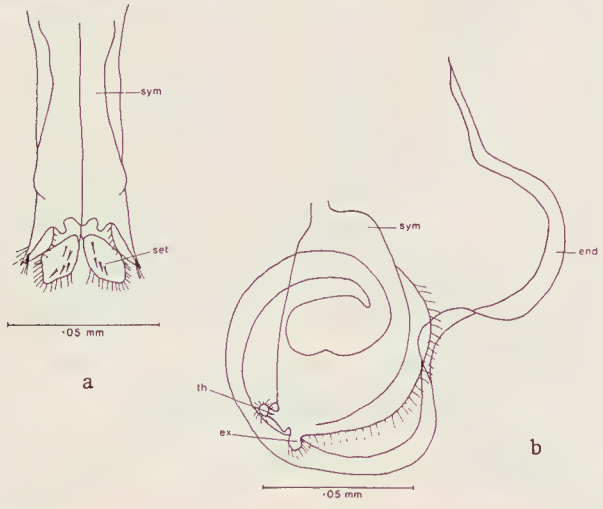

FIG. 5a. - pleopod I - male; sym-sympode, set-setaceous lobe.
5b. - pleopod II - male; end-endopodite, sym-sympode, ex-exopod, th-third structure. Depiction of the muscle structure is deleted to avoid confusion.

(a) Pleopod I - Male (Figure 5a): The first male pleopod consists of an elongated sympode, which is slightly dilated at the base and bears one pair of setaceous lobes. In *H. petrensis* there appears to be an inner lobe comparable with the structure described by Chappuis (1951)(fig. 14, p. 14 of his paper) as a bristly lobe. On dissection of *H. petrensis*, this lobe is found to be a structure within the pleopod. The first pair of pleopods is coupled with the second pair forming a tripartite operculum covering the remaining pleopods which are respiratory.

(b) Pleopod II - Male (Figure 5b): The second pleopod consists of a large sympode with the external margin convex and the internal margin straight. The external margin is fringed with simple setae. On the centre of the posterior side of each pleopod is the endopodite (appendix masculina), which is spiral in form and at least five times the length of the pleopod. The endopodite appears to be hollow, except for a chitinous reinforcement running along its external margin. The endopodite terminates in a fine point. The exopodite is reduced to a small projection bearing setae inserted on the apical margin of the pleopod. A third structure is present on the internal apical margin of the pleopod and it is fringed with setae. This structure was not mentioned by either Sayce (1900) or Chappuis (1951). It appears to

be a definite structure inserted inside a cavity. In live specimens, it is often protruded. Its function at this time is unknown, but it may be a copulatory structure, since a penial stylet (Chappuis 1951) was not found between the seventh pereopods such as that of *Pseudasellus nicholisi*. The sympode is highly muscular, possessing many muscle bands which are attached to the external and apical margin of the sympode. At least one muscle band is isolated from this system and links the base of the endopodite to the base of the protruding structure.

(c) Pleopod II - Female (Figure 6a): Both pleopods of the second pair are fused without a trace of a suture to form a common operculum, which completely covers the following pairs of pleopods. The pleopod is round, with a rounded median protruberance at its distal extremity, and has a setaceous margin. A row of setae is present on either side of the median line and a second row of setae is present just inside the distal margin.

(d) Pleopod III (Figure 7a): The third pleopod is biramous and similar in both sexes. It bears a well developed exopodite which is one third longer and wider than the endopodite. The exopodite is divided into two sections by a suture and has a setaceous margin. At its apical extremity the exopodite bears one or two strong simple setae. The endopodite is not divided by sutures and lacks setae.

(e) Pleopod IV (Figure 7c): The fourth pleopod is biramous and similar in both sexes. The exopodite is one third longer and one third wider than the endopodite. The exopodite tapers distally and terminates in a rounded tip, which bears several simple setae. Setae are slo present on the internal margin of the exopodite. The endopodite is oblong-ovate and lacks setae.

(f) Pleopod V (Figure 7b): The fifth pleopod is uniramous and similar in both sexes. It is composed of a protopodite and an oval endopodite. The exopodite is absent. The endopodite is non-setaceous.

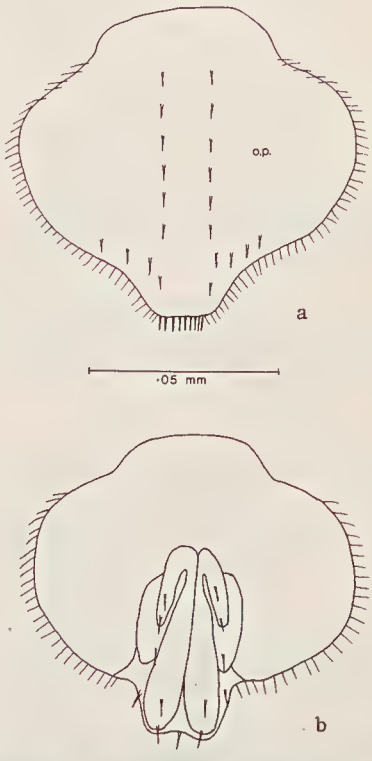

FIG. 6a. - pleopod II - female; op-operculum.
6b. - pleopod II - female intersex.

(g) Uropods (Figure 2c): The uropods are attached termo-laterally to the pleotelson. Each is cylindrical and composed of three parts, protopodite (peduncle), exopodite (outer ramus) and endopodite (inner ramus). The uropods are just shorter than the pleotelson. The ratios of uropod length to pleotelson length are, 1:1.32 for males and 1:1.22 for females. The endopodite is longer than the exopodite, which is longer than the protopodite. The ratios of endopodite length to exopodite length to protopodite length are 7.52:5.12:4 for males and 7.86:4.81:4 for females. The uropods bear setae on their lateral margins and a tuft of seven setae on the distal ends of the exopodite and endopodite. Several plumose setae are present on the lateral margins of the endopodite and one on the lateral margin of the exopodite.

(h) Intersexes (Figure 6b): Among the specimens examined, intersexes, predominantly bearing female characteristics were not infrequently found. The first male pleopod was more or less developed, but was never as differentiated as that of the adult male.

The second pleopod was of a similar shape to the female operculum. The pleopod is transparent and lobes are clearly visible. Similar intersexes were found by Chappuis (1951) in *Pseudasellus nichollsi* and he tentatively suggested that these lobes represent the endopodite and exopodite of the second male pleopod.

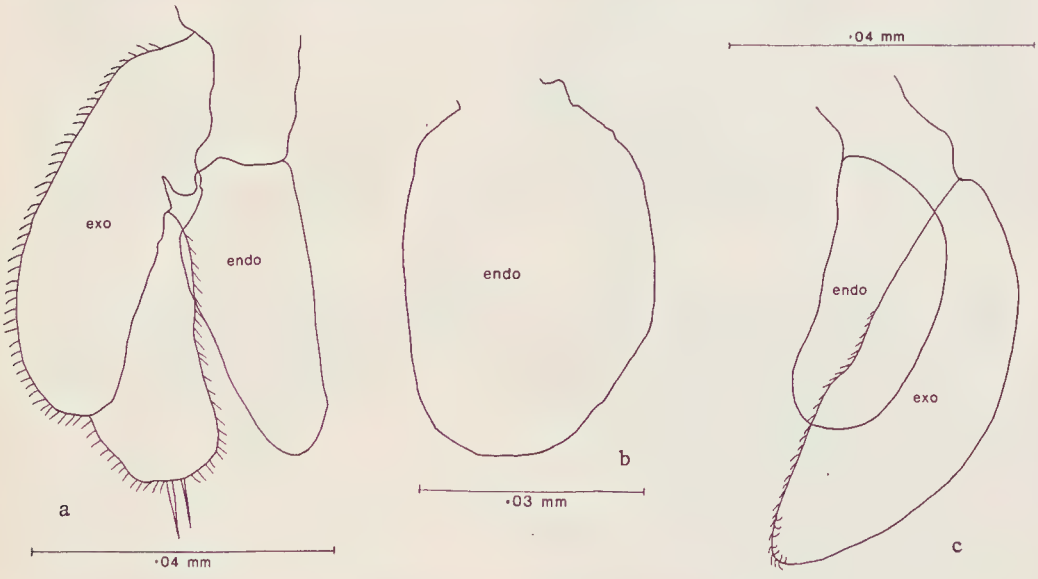

FIG. 7a. - pleopod III - male; endo-endopodite, exo-exopodite.
7b. - pleopod V - male; endo-endopodite, exo-exopodite.
7c. - pleopod IV - male; endo-exo-exopodite.

REMARKS

The most noticeable differences between *Heterias petrensis* and *Heterias pusilla* are summarized in table 1.

As a result of comparing *H. petrensis* with *H. pusilla* it appears that they are similar in enough characters to be considered as belonging to the same genus, *Heterias* (Sayce 1900). However they warrant being considered as different species.

H. petrensis from Lake Crescent lives on the underside of rocks in less than 30 cm of water, being most abundant in water less than 15 cm in depth. *H. petrensis* is herbivorous, feeding on algae and possibly on dead and decaying leaves. The species is also found in Lake Sorell.

The new species, *Heterias petrensis* possesses many characters similar to *Heterias pusilla*, *Heterias exul* and *Pseudasellus nichollsi* as well as possessing characters dissimilar from each.

From *H. pusilla*, *H. petrensis* differs in (1) the form of the male and female, (2) the presence of eyes, (3) the exopodite of the uropoda are not shorter than the peduncle but longer than the peduncle, (4) the shape of the base of pleopod I (see figs. 5, 8d).

From *H. exul*, *H. petrensis* differs in (1) the form of the male and female, (2) the

TABLE 1

Some major differences between *Heterias petrensis* and *H. pusilla*

	H. petrensis	*H. pusilla*
Eyes	present	absent
Widest segment - female	sixth pereonite	third pereonite
male	seventh pereonite	pleotelson
Mandibular palp	setae on 2nd joint doubly pectinated	setae on 2nd joint "spatulate with margins delicately feathered"
	3rd joint of the palp bears one strongly doubly-pectinated setae at its distal end and 18 doubly-pectinated setae.	3rd joint of the palp bears "three plumose setae, and six short stout plumose setae".
Dactylus	secondary claw just shorter than major claw.	secondary claw extremely small.
Uropods	exopodite longer than the peduncle.	exopodite is very short, shorter than the peduncle.
Pleopod I	see diagram fig. 5a.	see diagram fig. 8d.
Pleopod III	exopodite one third wider and longer than endopodite.	exopodite 3x wider and 2x longer than endopodite.
Pleopod IV	exopodite one third wider and longer than endopodite.	exopodite 2x wider and 1½x longer than endopodite.
Pleopod V	oval.	oblong ovate.

extent of the expansion of the distal end of pleopod I (see figs. 5a, 8c), (3) the extent of the elongation of the endopodite of male pleopod II (figs. 8a, 5b).

From *P. nichollsi*, *H. petrensis* differs in (1) the form of the male and female, (2) the presence of eyes and body pigmentation, (3) the antennae length is not less than, but greater than body length, (4) the exopodite of the uropod is not shorter than but longer than the peduncle, (5) pleopod I does not bear two pairs of bristly lobes at the base of the pedunlce, but one pair of setaceous lobes, (6) the form of the male pleopod II (figs. 8b, 5b).

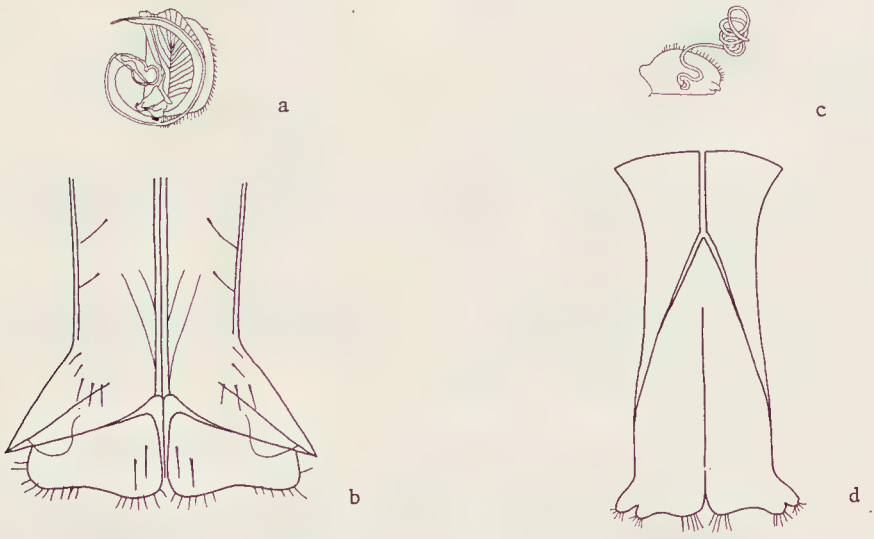

FIG. 8a. - *Janiropsis exul* (Muller 1892) - details of male pleopod II.
8b. - *Janiropsis exul* (Muller 1892) - terminal part of male pleopod I.
8c. - *Pseudasellus nichollsi* (Chappuis 1951) male pleopod II.
8d. - *Janirella pusilla* (Sayce 1900) - male pleopod I.

ACKNOWLEDGEMENTS

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PLANT SPECIES DIVERSITY OF THE LAKE DORA ISLANDS, TASMANIA

by J.B. Kirkpatrick

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(with three text-figures and one plate)

ABSTRACT

The relationship between the areas and plant species number of sixteen small islands in a Tasmanian subalpine lake is described. The nature of the island area species diversity curve seems to be strongly affected by island area rather than habitat heterogeneity, and by differences in species diversity in the vegetation zones found on the island.

INTRODUCTION

Lake Dora is one of the largest of many lakes which fill the basins in a glacially eroded 'knock and lochan' landscape in a part of north-western Tasmania receiving more than 3000 mm of precipitation per annum. The lake is 750 m above sea level and contains sixteen small islands (fig. 1) which vary in size from five sq. m to 375 sq. m. Some of these islands are apparently *roches moutonnees*, but most are Cambrian volcanic rock outcrops of slightly higher altitude than the lake surface.

The islands have biogeographic interest in that: they vary markedly in size while being all very small; their vegetation has developed under almost identical edaphic and climatic conditions; and the hinterland of the lake is covered by a vegetation which differs markedly in both floristics and structure from that of the islands. Thus, they offer the opportunity to provide substantive data relevant to theories of island biogeography from a relatively unusual situation.

METHODS

Species lists were made of all Pteridophyta, Gymnospermae and Angiospermae found on each island in late January 1973. Nomenclature in this paper follows Curtis (1956, 1963 and 1967) for the Gymnospermae and Dicotyledoneae, and Willis (1970) for the Pteridophyta and Monocotyledoneae excepting the Tasmanian endemics for which authorities are given (Appendix). The areas of the islands were measured from large scale aerial photographs.

RESULTS AND DISCUSSION

Fifty-five species were found on the islands of which 28 were Tasmanian endemics (Appendix). The number of species on individual islands varied from 12 to 32.

The number of species per island increases linearly to an island size of 36 sq. m (fig. 2). The correlation coefficient for the relationship between species number and island area including only islands to this size is 0.9069 ($0.001 < p < 0.002$). The larger islands exhibit virtually no increase in species diversity with increasing area (fig. 2), this being reflected in the fact that forty-seven of the fifty-five species recorded for the islands are found on at least one of the islands 36 sq. m and under in area (fig. 3).

The sharp increase in species number with area on the smaller islands is partially

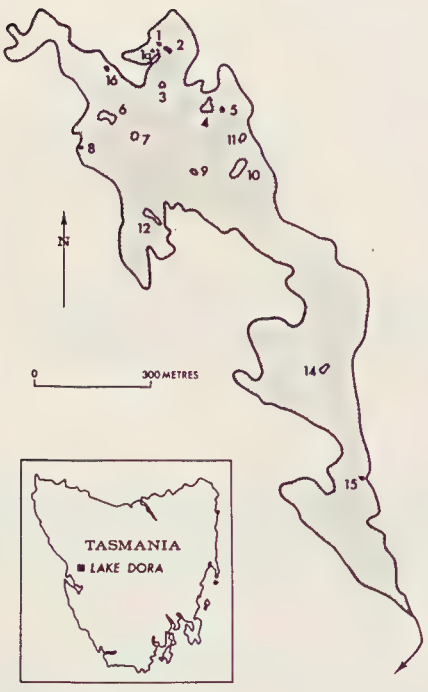

FIG. 1. - Location and coding of islands.

due to the islands being so small that they do not attain the minimal area for the island vegetation type. The lack of space for growth on these islands limits the number of plants that can co-exist and this in turn limits the number of species. This is particularly important as many of the 55 species found on the islands are shrubs attaining diameters of over one metre and heights of over two metres.

As could be expected following from this argument, the correlation between island species number and island area up to 36 sq. m is improved by excluding herbs ($r = 0.9146$, $0.001 < p < 0.002$), and even the disparities in species number between the larger islands are reduced (fig. 2). Thus, the rapid increase in species number with increase in island size up to 36 sq. m is partly area controlled, rather than being controlled entirely by habitat heterogeneity.

The flattening of the species diversity/area curve past 36 sq. m is a product of the nature of the response of the island vegetation to increased habitat heterogeneity. Three vegetation zones can be distinguished on the islands, only one of which is fully developed on all. Below the extreme high water mark are found three species; *Restio tetraphyllus* which forms a fringing rhizome mat, *Baeckea gunniana* which grows among the rushes in shallower water, and the endemic gymnosperm *Diselma archeri* which is found close to the high water mark. The second zone consists of a 2 - 4 m high dense and tangled growth of shrub species, with an occasional emergent 5 - 7 m tall tree of ice-abraded *Athrotaxis cupressoides* (plate 1). This second zone is well developed on all but the two smallest islands, although the species richness of the zone increases to an island size of 36 sq. m. The presence of the third zone on an island depends on the island being large enough to have habitats protected from the effects of strong ice-laden winds. This zone consists of the climax vegetation for the altitude and rainfall of the islands. This vegetation is not as species rich as the vegetation of the second zone, and many of the species found in the second zone are also found in the third. Only five species are confined to the third zone on the islands, and only three of these species are found on more than one island. Almost all the species found in the climax forest at similar altitudes in non-lacustrine areas are found on the islands. Thus, any further increase in island size would almost certainly not involve a marked increase in species number.

One of the more interesting features of the floristic composition of the island vegetation is the presence of a number of species which are not usually found in areas undisturbed by fire. These species are abundant in the scrubs, sedgelands and moorlands which are produced by a history of relatively frequent firing (Jackson 1968). Most of the plateau on which Lake Dora is situated is covered by scrub, sedgeland and moorland, with some areas of rainforest in early stages of succession in situations normally sheltered from fires, and with eucalypt dominated communites found in well-drained rocky areas. The islands appear to have escaped the deflecting influence of fire, along with a small section of the southeast shoreline of the lake which is

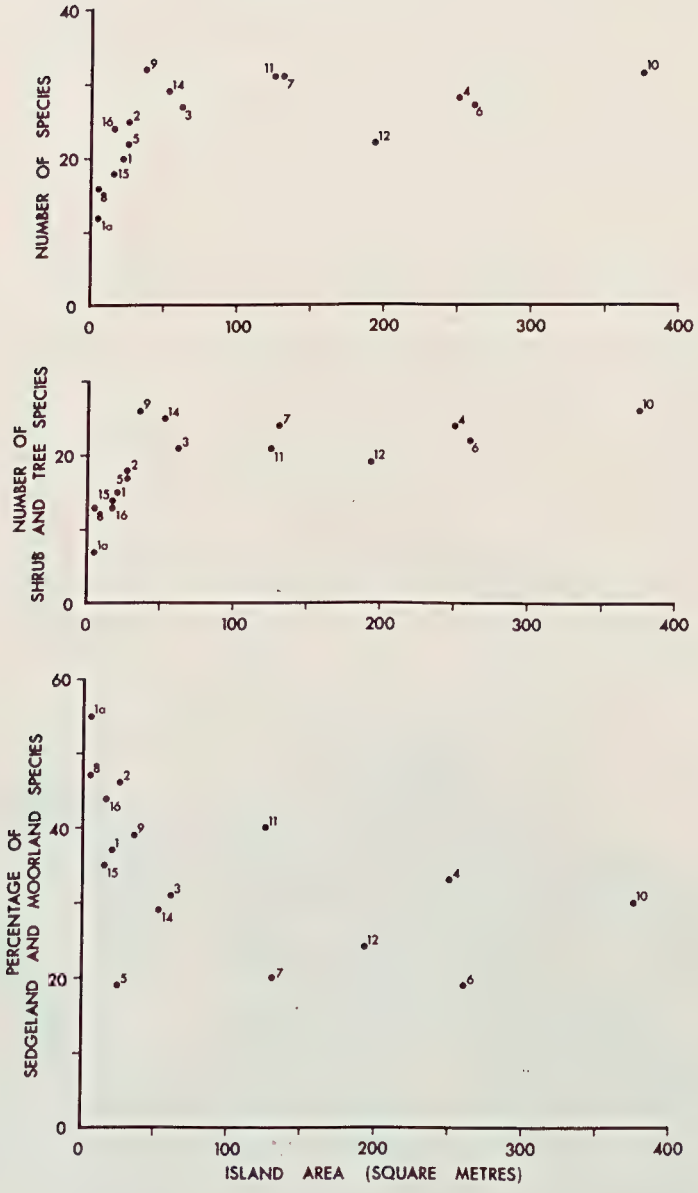

FIG. 2. - The relationship between species number and island area (top); the relationship between shrub and tree species number and island area (middle); the relationship between the number of species usually confined to fire disclimax communities and island area (bottom).

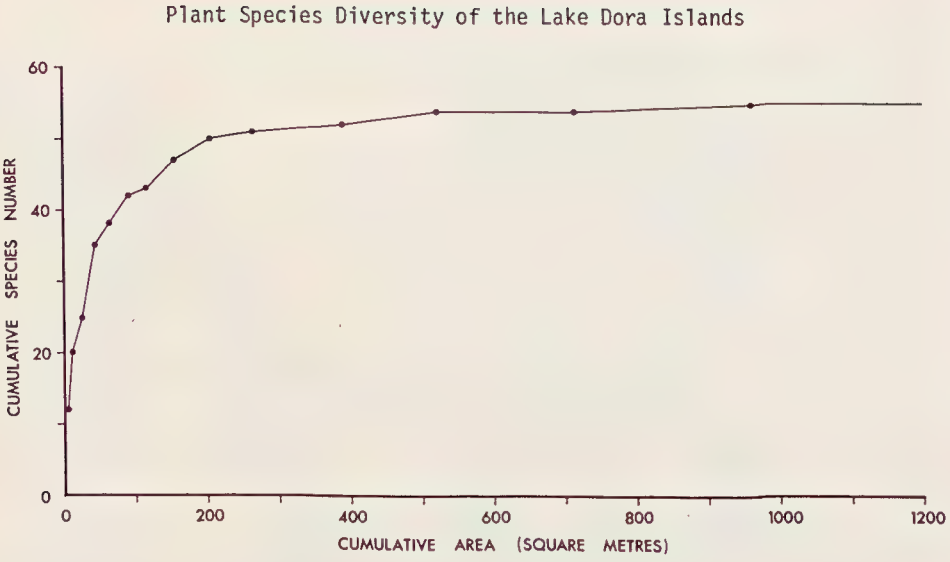

FIG. 3. - The cumulative species/area curve for the Lake Dora islands. No extra species were found on the largest two islands.

PLATE 1. - Typical vegetation of the larger islands showing zones. The figure leaning on an individual of *Athrotaxis cupressoides* is 2 m tall.

sheltered from the fire-associated westerly and northwesterly winds by the water-body. The major evidence for lack of at least recent fire on the islands is the widespread presence of the gymnosperms *(Athrotaxis cupressoides, A. selaginoides, Diselma archeri* and *Phyllocladus asplenifolius)* and the winter deciduous angiosperm *Nothofagus gunnii.* These species are all extremely fire sensitive and seem capable of only slow peripheral recolonization of burnt areas. They are also very slow growers, yet mature specimens are the rule rather than the exception on the islands. Some recent deaths of some of these species have occurred, resulting in extinction on one or two of the smaller islands, but the deaths were almost certainly the product of other causes than fire.

The conversion of the lakeshore vegetation from temperate rainforest to scrub, sedgeland and moorland would have taken place at least several decades ago as the skeletons of the *Athrotaxis* species are reasonably durable, and are absent throughout most of the area. The conversion may have resulted from aboriginal firing, but probably resulted from firing by prospectors in the nineteenth century, as the aboriginals appear to have rarely frequented the high rainfall montane areas, most of their archeological remains being concentrated along the coast and in the dry east of Tasmania (Bryden and Ellis 1965). Before the conversion took place plant extinctions on the lake islands would have been compensated by immigration from the similar shore vegetation. Since the conversion the incoming disseminules carried by the prevailing westerlies have been those of moor and sedgeland species. Thus, it could be expected that the smallest islands, which should experience the highest extinction rates owing to low populations of individual species (McArthur and Wilson 1967), would have the highest proportions of moorland and sedgeland species in their floras. The bottom graph of figure 2 shows a tendency towards this relationship, with island 5 being the main exception. However, this island is situated to the leeward of one of the largest islands (fig. 1), and thus would receive most of its disseminules from this source.

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for APPENDIX see over

APPENDIX

Species collected from the Lake Dora Islands, Tasmania

e = Tasmanian endemic; s = shrub or tree species; m = usually confined to scrub, moorland or sedgeland.

GRAMMITIDACEAE: *Grammitis armstrongii*
PODOCARPACEAE: *Phyllocladus asplenifolius* es
CUPRESSACEAE: *Diselma archeri* es
TAXODIACEAE: *Athrotaxis cupressoides* es, *A. selaginoides* es
GRAMINEAE: *Microlaena tasmanica* Hook. em, *Poa gunnii* J.W. Vickery em
CYPERACEAE: *Gahnia grandis*, *Gymnoschoenus sphaerocephalus* m, *Lepidosperma filiforme* m, *Tetraria capillaris* m
RESTIONACEAE: *Calorophus lateriflorus* m, *Restio complanatus* m, *R. tetraphyllus*
LILIACEAE: *Astelia alpina*, *Blandfordia punicea* (Labill.) Sweet e
AMARYLLIDACEAE: *Campynema lineare* Labill. e
IRIDACEAE: *Diplarrena moraea* m
ORCHIDACEAE: *Thelymitra cyanea* m
WINTERACEAE: *Drimys lanceolata* s
PITTOSPORACEAE: *Billardiera longiflora* s
LEGUMINOSAE: *Oxylobium ellipticum* s
CUNONIACEAE: *Anodopetalum biglandulosum* es, *Bauera rubioides* sm
ESCALLONIACEAE: *Anopterus glandulosus* es
EUCRYPHIACEAE: *Eucryphia milliganii* es
DROSERACEAE: *Drosera binata* m
MYRTACEAE: *Baeckea gunniana* s, *Eucalyptus subcrenulata* esm, *Leptospermum nitidum* sm, *Melaleuca squamea* sm
COMPOSITAE: *Olearia alpina* es
EPACRIDACEAE: *Archeria serpyllifolia* es, *Cyathodes juniperina* s, *C. petiolaris* es, *Epacris serpyllifolia* s, *Monotoca scoparia* var. *submutica* s, *Pentachondra pumila* s, *Prionotes cerinthoides* es, *Richea pandanifolia* es, *R. scoparia* es, *Sprengelia incarnata* sm, *Trochocarpa cunninghamii* es, *T. gunnii* es.
MONIMIACEAE: *Atherosperma moschatum* s
PROTEACEAE: *Agastachys odorata* es, *Banksia marginata* sm, *Cenarrhenes nitida* es, *Lomatia polymorpha* es, *Orites milliganii* es, *Persoonia gunnii* es
THYMELACEAE: *Pimelea lindleyana* esm
SANTALACEAE: *Exocarpos humifusus* es
FAGACEAE: *Nothofagus cunninghamii* s, *N. gunnii* es

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A NEW SPECIES OF FRESHWATER AMPHIPOD, *PARACALLIOPE LARAI*, (FAMILY EUSIRIDAE) FROM TASMANIA

by Brenton Knott

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(with two tables, one graph and 25 text-figures)

ABSTRACT

A new species of freshwater amphipod, *Paracalliope larai*, is described, the first description of a species of the genus *Paracalliope* from Tasmania. *P. larai* is found in the Dip River, north-western Tasmania. The distribution of the genus in Tasmania is briefly discussed.

INTRODUCTION

In 1879, Thomson described *Calliope fluviatilis*, a species of freshwater amphipod which was common in the Dunedin area, New Zealand. Later, Stebbing (1899) made this species the type for the new genus *Paracalliope* within the family Calliopiidae. In the same paper, Stebbing (1899, p. 210) stated that he considered *Pherusa australis* Haswell 1881 from Botany Bay, N.S.W., to be identical with *C. fluviatilis* and that both species probably are synomyms of *Oedicerus novizealandiae* Dana 1853 and 1855 (of the family Oedicerotidae). Barnard (1972a) referred *Oedicerus novaezealandiae* Dana to *Paracalliope novizealandiae* (Dana). The conflict as to the correct familial placement of the genus *Paracalliope* within amphipod phylogenetic lineages is yet to be resolved. Barnard (1972b) recently expanded the definition of the family Calliopiidae and included it in the family Eusiridae and has thus tentatively placed the genus *Paracalliope* in the family Eusiridae, but states that '*Paracalliope* cannot be written off completely and returned to the Eusiridae until further evaluation of other atypical oedicerotids is undertaken', (Barnard 1972a, p. 72).

Paracalliopes are now known from the freshwater, *(P. fluviatilis)*, brackish *(P. karitane)*, and marine *(P. novizealandiae)* environments of New Zealand (Barnard 1972a); from brackish *(P. indica)* waters of India (Sivaprakasam 1970); from freshwater areas *(P. novaecaledoniae)* of New Caledonia (Ruffo & Paiotta 1972); and from the Philippines *(P. fluviatilis)* (Chilton 1920). This paper extends the known geographical range of the genus to include Tasmania.

Although there have been several studies of Tasmanian freshwater amphipods. for example those of Thomson (1893), Smith (1909) and Straskraba (1964) on neoniphargids and those of Hurley (1959) and Williams (1962) on the austrochiltonids, there has been no indication that amphipods of the genus *Paracalliope* occur in Tasmania. However, during the past few years, collections of paracalliopes have been made from many brackish and freshwater localities in King and Flinders' Islands and Tasmania. The present paper describes a new species of freshwater *Paracalliope*, *P. larai*, from the Dip River, north west Tasmania.

METHODS

The paracalliopes were collected from the Dip River immediately upstream from the Dip River Falls (41° 1'S; 145° 23'E, alt. approx. 200 m) by dislodging rocks and collecting the amphipods in a Freshwater Biological Association net held downstream. The animals were returned alive to the laboratory where they were preserved in a solution of 5% glycerol in 70% alcohol.

Dissections were performed using needles, and the appendages were mounted in lactophenol for microscopic examination. To clarify details of segmentation and structure, the relevant portions were treated overnight at room temperature in 10% KOH and either stained in lignin pink and mounted on slides in Canada Balsam or mounted in polyvinyl alcohol.

Twenty mature specimens of each sex were studied.

DESCRIPTION

The following description of *P. larai* is applicable, except where especially stated, to either sex, male or female.

Body

The males are lighter in colour than the females. Both sexes are brown with peraeonites 3 and 4 and pleonites 1 to 3 appearing as non-pigmented stripes. The colour pattern of preserved specimens changes slowly to creamy-white during a period of 3-4 months in 70% alcohol.

The body surface is quite smooth, lacking tergal carinae. Setae are restricted to the appendages and to areas near the margins of the abdominal epimera.

The tergite of pleonite 4 is curved concavely (fig. 5), although this feature is not always so obvious in the female. Pleonite 3, and the coalesced pleonites 5 and 6 are similarly curved, but to a considerably lesser degree (fig. 5).

There is a marked sexual dimorphism in overall body length. The males (figs. 1 and 3) are longer than the females (figs. 2 and 4; see also table 1). In both sexes, the coxal side plates bulge beyond the curvature of the tergites. The greatest width of the fusiform body, excluding the bulge of the coxal sideplates, occurs at peraeonites 4 and 5 in both males and females (see table 1 for measurements). As shown in Graph 1, there is no obvious difference with respect to the allometry of length (head-peraeon)/ breadth ratios between males and females. The rostrum - telson length of males averages 3 mm, and of females, 2 mm.

Head

The head is produced into a short rostrum. The cephalic lobe, (cl fig. 6) which projects just beyond the extension of the rostrum, may vary in shape; rounded (fig. 4) to sharply pointed (figs. 3 and 6). The laterally placed, widely separated eyes have an irregular outline, but are approximately square in shape. The eyes are many faceted and do not protrude above the contour of the head.

In overall length, antenna 2 (fig. 7) is longer than antenna 1 (fig. 8), although the flagella of both antennae are subequal in length. Setae are confined to the distal margins of the antennal segments.

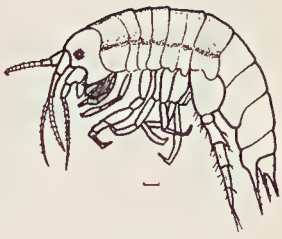
The most conspicuous segment in antenna 1 (antennule) is the basal (first) segment. Succeeding peduncular segments show a successive decrease in both length and breadth so that the flagellar segments, all of similar dimensions, are not noticeably different from the third peduncle segment.

In accord with the typical amphipod facies, antenna 2 has a peduncle of 5 segments, although segments 1 and 2 are incompletely divided, and together appear as a unit 1½ times greater in width than length. Peduncle segments each show a successive decrease in width. Segments 4 and 5 are subequal in length, and each is longer than any of the remaining segments in the antenna. Segment 1 in the flagellum of antenna 2 is longer than the remaining segments. The flagellum is noticeably distinct from the peduncle. The range in the number of flagella segments of both antennae is shown in table 1.

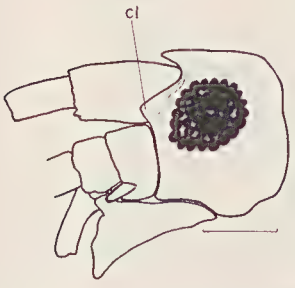
1 Male, dorsal view

3 & 5 Male, lateral view

2 Female, dorsal view

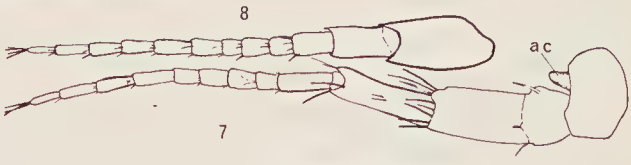


4 Female, lateral view

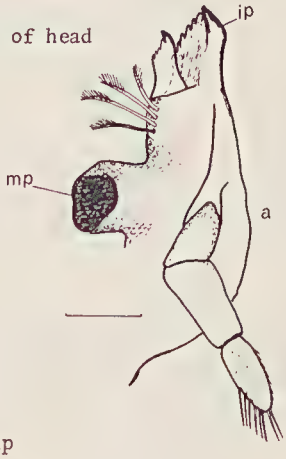


6 Male, lateral view of head

8 Male, antenna 1



7 Male, antenna 2

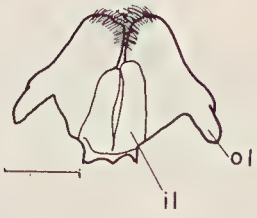


9a & b Male, upper lip

10a Male, mandible

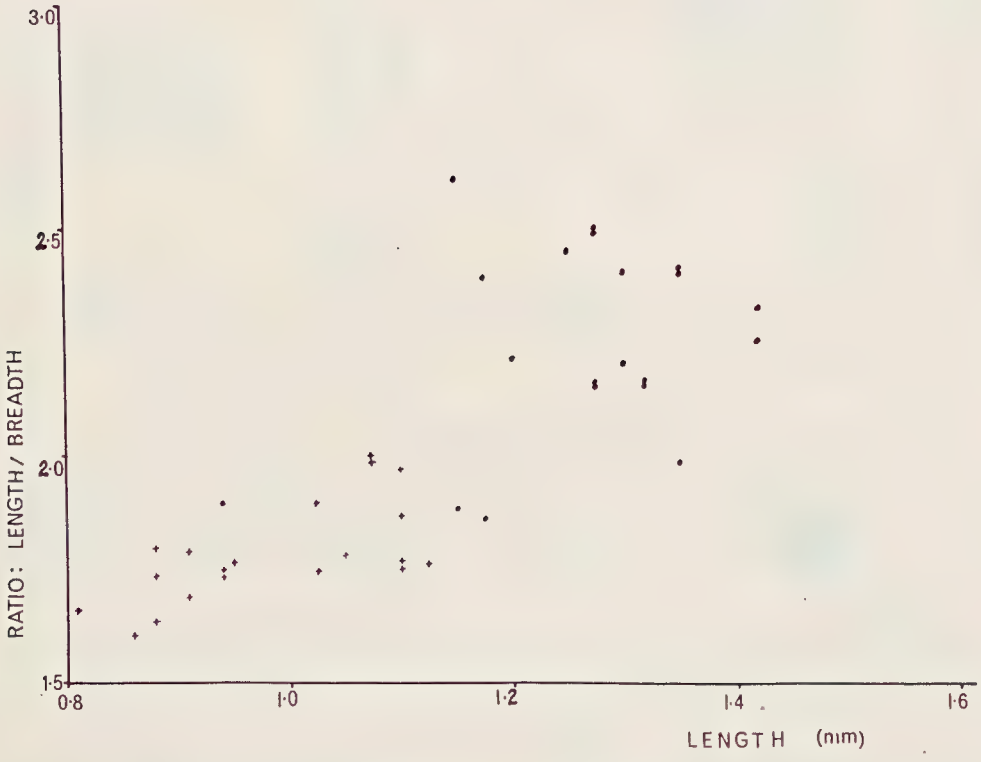
b Male, mandible, freehand drawing of opposing lacinia

c Male, mandible, 3rd joint of palp



11 Male, lower lip

In each figure, a scale of 0.1 mm is also given



GRAPH 1. - Graph showing the relationship between the ratio of length-breadth to the length of the amphipod.
dots - males; plus signs - females.

On the second peduncle segment of antenna 2 is the antennal cone (ac fig. 7). This cone exhibits a distinct sexual dimorphism with regard to its length, being as long as or longer than peduncle segment 3 in females, but being no longer than half the length of the adjacent third segment in males.

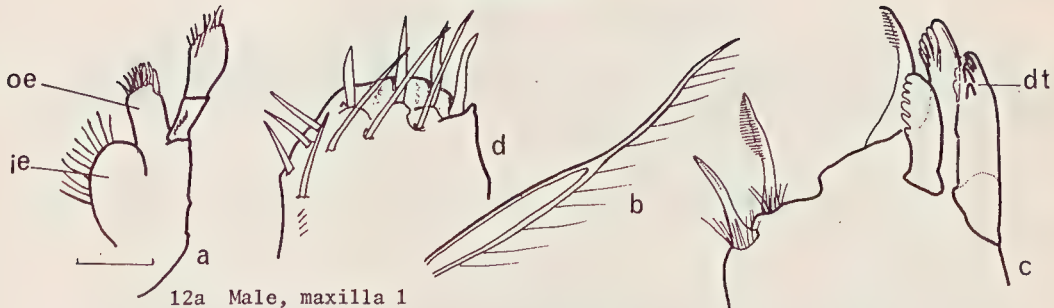
Calceoli are present on the antennae of males. Calceoli are found on flagella segments 1, 2, and 4 (Antenna 1) and flagella segments 1, 2 and 4 (Antenna 2). Although in the majority of paracalliopes examined, the calceoli on any one antenna were identical, there are usually two types of calceoli on one single male paracalliope. Only one exception has been observed; in this specimen, all the calceoli were the same. This phenomenon of asymmetry of calceoli expression is currently the subject of further study (D. Coleman, pers. comm.). The females lack calceoli.

Upper Lip

This is sometimes skewed (fig. 9a), but is usually evenly rounded (fig. 9b).

Mandible

Both mandibles have a well developed lacinia mobilis, although one lacinia is generally a dentate process (fig. 10a), whilst the opposing lacinia is a spike (fig. 10b). The spine row may have one seta, or a row of several setae. Both the triturating molar (mp) and biting incisor processes (ip) are well developed.



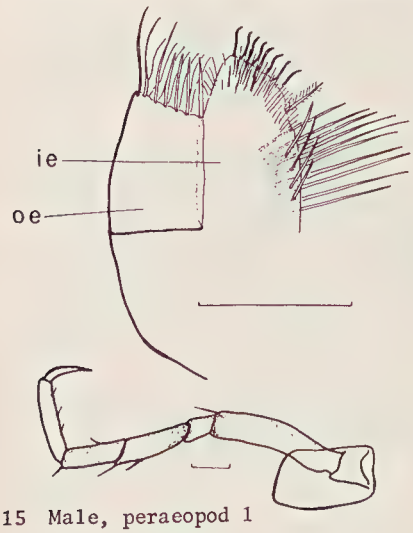
12a Male, maxilla 1

b Male, maxilla, freehand drawing of apical region of outer endite

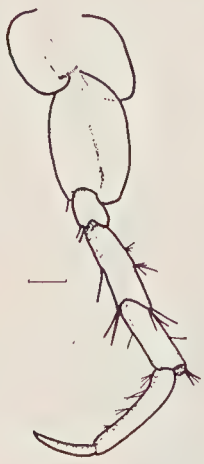
c Male, maxilla, freehand drawing of seta from inner endite

d Male, maxilla, freehand drawing of apical region of palp

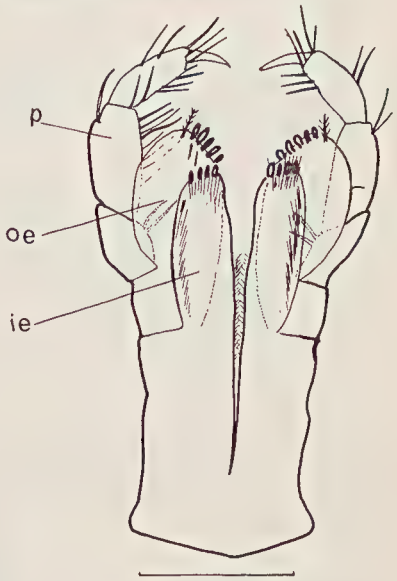
13 Male, maxilla 2 left side, anterior view



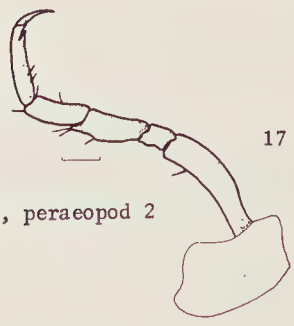
15 Male, peraeopod 1



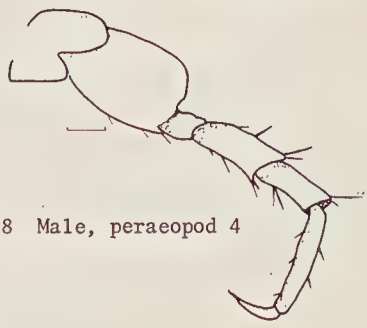
17 Male, peraeopod 3



14 Male, maxilliped



16 Male, peraeopod 2



18 Male, peraeopod 4

Each mandible carries a three segmented palp, the middle segment being the longest in the palp. The distal segment in the male is equipped with 6-9 long setae (fig. 10a), but in the female only 2 setae are present (fig. 10c). These setae on the mandibular palp are figured in diagram 10d.

The Lower Lip

The outer (mandibular) lobes (ol) and the inner lobes (il) are both well developed (fig. 11).

Maxilla I (maxillula)

This is formed from an inner (ie) and outer (oe) endite, the latter bearing a 2 segmented palp on its anterior surface. The inner endite carries long plumosetae (fig. 12b) along the medial margin.

There are 9-11 stout teeth along the free end of the outer endite. The lateral 3 teeth are dentate (dt fig. 12c) and are closely adpressed; the remaining teeth bear comb structures with the 2 teeth closest to the medial margin of the endite carrying hair setae, basally.

The distal segment of the palp is larger than the proximal segments, and is armed terminally (fig. 12d) with 2 rows of trichia - a submarginal row of 4 spines and 3 medial setae, and proximal to this submarginal row, a line of setae obliquely crossing the mesodistal corner of the segment.

Maxilla 2

This is formed from two simple lamellar endites. The outer endite (oe) (fig. 13) is shorter than the inner endite (ie) and carries, apically, a double row of setae. The setae of the anterior row are fine and hooked terminally, whilst those of the posterior row are straight and stouter than the others. The inner endite is carried at an angle to the outer endite. One plumoseta is present at the vaguely defined mesodistal corner of the endite. Distal to this plumoseta is a row of hooked setae; proximally there may be a row of simple setae. Obliquely across the anterior surface of the inner endite is a row of long simple setae.

Maxilliped

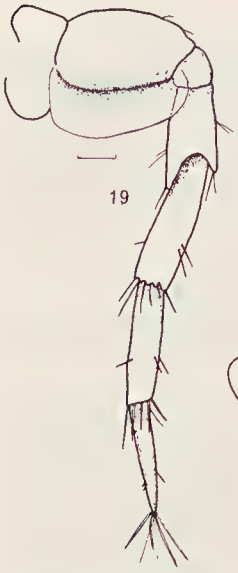
This is normal, with well-developed 4 segmented palp (p) (fig. 14). The palp is sparsely setose. The outer endite (oe) bears one plumoseta terminally, and a row of spatulate processes along the margin medial to this. The inner endite (ie) carries an apical row of similar processes. There may be a row of fine hairs near the base of the inner endite.

Peraeon

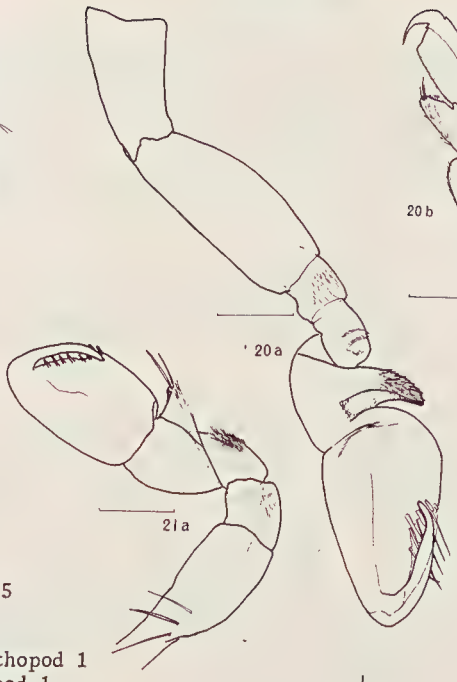
Peraeonites 1-6 are subequal in length; peraeonite 7 is slightly longer. The approximately rectangular coxal sideplates of the first four peraeonites are well developed; the fourth coxal sideplate is weakly excavate posteriorly.

No sexual dimorphism is evident in peraeopods 1 to 5 which are sparsely setose (figs. 15 - 19 respectively) and are quite slender. Peraeopod 5 (fig. 19) is noticeably longer than the alternative peraeopods and the dactyl is straight. The basipodites are longer, and are expanded posteriorly on peraeopods 5, 6 and 7. The ischiopodites are small. On peraeopods 1 - 4, the meropodite and carpopodite show a small difference in length, and the two terminal segments tend to be long and slender. On peraeopod 5, the carpopodite is longer than the meropodite and articulates between two prominent disto-laterally projecting lobes of the meropodite; the dactyl is straight, and shorter than the propodite (see table 1). Simple lamellate oostegites are found at the base of the coxae of peraeopods 2 - 5 inclusive on gravid females.

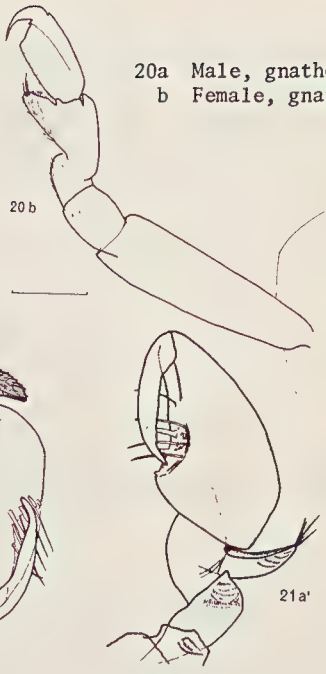
In males, Gnathopod 2 (fig. 20a) is larger than gnathopod 1 (fig. 21a) but both



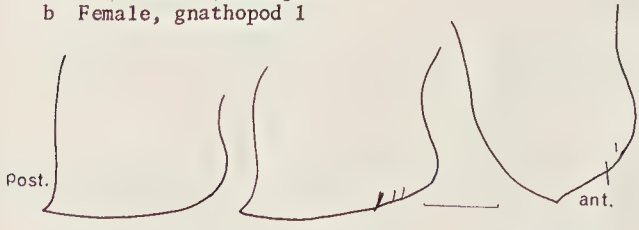
19 Male, peraeopod 5



21a & a[1] Male, gnathopod 1
b Female, gnathopod 1

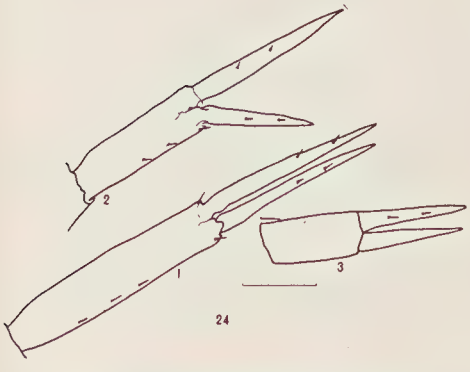


20a Male, gnathopod 2
b Female, gnathopod 2

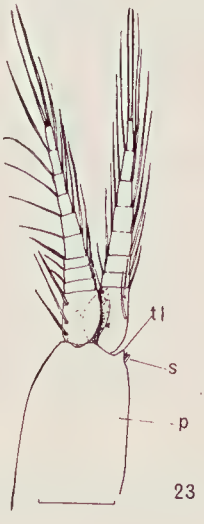


22 Male, abdominal epimera

22



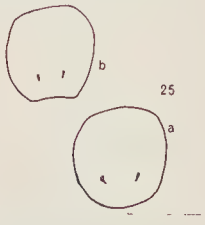
24a, b, c Male, uropoda 1, 2, 3



23

23 Male, pleopod 1

anterior view.



25a, b Male, telson

gnathopods are the same size in females (figs. 20b and 21b respectively). All gnathopods are subchelate. Basipodites are long and, except in the case of female gnathopod 1, devoid of setae. The ischiopodites and meropodites are shorter; the carpopodite is twisted and expanded posteriorly into a prominent lobe. The palm of the propodite, although showing some variation in expression (fig. 21a and a^1), is well developed in the male and carries teeth; in the female, the palm is poorly developed and carries only setae. The dactyl is quite simple. The forward surfaces of the ischios, meros, carpos and propos have bands of very fine hairs, with a tuft of simple setae being carried apically on the carpal lobe.

Pleon

Pleonites 1 - 3 are equal in length and are the longest segments in the body of the amphipod. Pleonites 5 and 6 (urosomites 2 and 3 are coalesced. No sexually dimorphic features are evident in the pleon.

The epimera on the first 3 pleonites (fig. 22) are rounded at the antero-distal extremity, and have submarginal setae. The posterior-lateral margin of the epimera of pleonite 1 is convex, but is concave on pleonites 2 and 3 and the posterior-distal corner of these latter two epimera are sharply pointed.

The three pairs of pleopods are similar in form. The approximately rectangular peduncle (p, fig. 23) has an almost straight inner margin, but the outer margin is curved inwards distally. At the meso-distal margin on the anterior surface of each peduncle, there is a small triangular lobe (tl, fig. 23) which, when viewed from the anterior aspect, partially covers the pair of toothed spines (s, fig. 23) found in the 3 pairs of pleopods. A long simple seta is found on the anterior surface of the peduncle proximal to the base of the inner ramus.

Each pleopod has two multisegmented rami. The first segments of each ramus are the longest segments in the rami, the inner ramus having a conspicuously large (under the microscope) nucleus at the position marked x in fig. 23.

A posterio-lateral expansion of the basal segment of the inner ramus abuts a boss on the outer endite. The apical segment of each ramus is truncated and terminates in two long plumosetae. The first segment of each ramus has one row of long setae directed anteriorly; the remaining segments each bear one long plumoseta at both of the latero-distal corners and lying in the plane of the pleopod.

Uropods

The three pairs of uropods are all well developed, each having a peduncle with 2 rami (fig. 24). Uropods 2 and 3 extend just beyond the limit of uropod 3. The basic patterns of the variation in relative lengths of the three components of each uropod, namely peduncle, inner ramus, and outer ramus are given in table 2.

There are setae (see table 2 for the range) along the dorsal outer margins, including the distal corner, of uropods 1 and 2, and one at the corresponding meso-distal corner on uropod 1. Only rarely were setae observed on the peduncle of uropod 3, and setae were not recorded from the inner meso-distal corner of uropod 2. Setae are also found on the inner ramus of all 3 uropods, but only on the outer rami of uropods 1 and 2.

The telson is entire and usually rounded (fig. 25a) but is sometimes slightly indented (fig. 25b).

Habitat

The collection site for these amphipods is at an altitude of approximately 200 m, 23 km in direct line from Bass Strait. The site is immediately upstream from a 40 m waterfall which marks an old fault in the Tertiary basalt sequences of the far north west of Tasmania.

The amphipods are found in mud, gravel and on the underside of rocks in the slowly flowing portion of the Dip River immediately above the falls. Unlike the austrochiltonids and neoniphargids of Tasmanian creeks which swim, paracalliopes tend to stay still, and move only infrequently in rapid spurts. They are undoubtedly propelled in this motion by their elongate 5th peraeopods.

Etymology

The species is named after the author's daughter, Miss L-L. Knott.

Collections

Material has been collected on the following dates from the type locality:
9. 2.1973 by P.S. Lake, R.B. Mawbey, A.M.M. Richardson and B. Knott.
5.12.1973 by R.B. Mawbey, A.M.M. Richardson, D. Coleman, P. Suter and B. Knott.
28.1.1974 by R.B. Mawbey, A.M.M. Richardson and B. Knott.
12.7.1974 by D. Coleman.

Type Material

Holotype: 1 adult male ; Allotype 1 gravid female.
Paratypes: 15 adult males and 15 adult females.
All types are from the collection 9.2.1973, and are deposited in the Tasmanian Museum, Hobart (reg. nos. G1624, G1625, G1626 and G1627 respectively).

DISCUSSION

The species of amphipod described in this paper undoubtedly belongs to the genus *Paracalliope* Stebbing as recently redefined by Barnard (1972a, pp. 70, 71):- "Rostrum small, not exceeding forward extent of lateral cephalic lobe; eyes large, paired, lateral, discontinuous; antennae proportionate; vestigial accessory flagellum present; flagellum of male antenna 1 with a few calceoli; mandibular incisor projecting, toothed, lacinia mobilis large toothed, molar large, cuboid, triturative; palp article 3 subfalciform normally; lower lip with well developed inner lobes; inner plates of maxillae 1 - 2 strongly setose medially, maxilla 2 with submarginal oblique setal row on inner plate; palp of maxilla 1 normal and 2 articulate; maxillipeds stout but otherwise basic in male; gnathopods subchelate, female gnathopods weak, those of male stout, fifth articles posteriorly lobate, lobes erect or not distinctly guarding hands, hands twisted medially, palms bearing large spines; peraeopods 1 - 4 with slender distal articles, poorly setose; coxa 4 not posteriorly excavate or weakly so; peraeopod 5 normally elongate for family Oedicerotidae, moderately setose, especially dactyl; pleonal epimera in posterodistal points; body dorsally smooth; uropods 1 - 3 all extending equally, outer rami of uropods 1 - 2 slightly shortened, peduncle of uropod 3 normally elongate, rami slightly shorter than peduncle; telson normally ovoid, thin, and uncleft; urosomites 2 - 3 coalesced".

All of these morphological features are expressed in *Paracalliope larai*, except for one, or possibly two minor differences. The vestigal accessory flagellum is lost completely in *P. larai* and the third uropod rami are subequal in length to the peduncle instead of being shorter. Neither difference is considered by the present author to be sufficiently distinct or important to raise doubts regarding the generic status of this Tasmanian material.

However, some doubt as to the family status of the genus has been raised by Barnard (1972a and b). Barnard (1972a, p. 71) recognised *Paracalliope* as an intergrade between the Eusiridae (Pontogeneiidae and Calliopiidae) and Oedicerotidae, although not being in the mainstream of calliopod evolution towards oedicerotids.

Until all of the Tasmanian freshwater "calliopid" material is examined, especially that from Lake Edgar, and the buttongrass areas of the West Coast, it would be presumptuous to propose any positive assertions or alterations to the family status as

proposed by Barnard (1972a and b) i.e. *Paracalliope* is retained here as a member of the family Eusiridae. Nevertheless, *P. larai* has a slightly more oedicerotid condition than the New Zealand materal described by Barnard (1972a). Thus *P. larai* has lost the vestigal accessory flagellum although Barnard regards this character as being of dubious familial value. Also, *P. larai*, and indeed, most Tasmanian paracalliopes select the habitat typical for oedicerotids, usually being found living in the benthos in the leaf litter, mud, and silt deposits of pools in streams, although sometimes found associated with aquatic plants. This is in contrast to the observations by Phillips (1929), Percival (1932) and Hirsch (1958), that paracalliopes in New Zealand are typically associated with weeds and aquatic plants in streams, and that they are a littoral, epifaunal inhabitant in the marine environment (Barnard 1972a). Otherwise, the characters evaluated by Barnard (1972a) in his attempt to elucidate the familial affinities of the genus *Paracalliope* remain unchanged in *P. Larai*.

P. larai is separated

(a) from the New Zealand species (see Barnard 1972a), by the absence of an accessory flagellum; by reduced setation of coxal plates, abdominal epimera and uropods, and the absence of the basal seta of the third segment of the mandibular palp.

(b) from *P. novaecaledoniae* (see Ruffo and Paiotta 1972) by absence of the basal seta of the third segment of the mandibular palp, reduced length of the outer lobe of maxilla 2; shape, spine and setal arrangement of the outer lobe of the maxilliped, shape of the abdominal epimera.

(c) from *P. indica* (see Barnard 1935) by reduced length of the third segment of the mandibular palp, by the reduced size of the second palp segment of the maxilliped, and the subequality of the rami of the third uropod.

Paracalliopes have been found in many localities in Tasmania, King Island and Flinders Island, extending inland in Tasmania as far as the base of the Central Plateau scarps but they are especially abundant in many of the coastal creeks around the south and east coast of Tasmania where they appear to be restricted to small, ionically enriched creeks flowing over sandstone and mudstone. No paracalliopes have been found on the Central Plateau where they are probably excluded because of the low ionic concentration of the waters (table 2, in Buckney and Tyler (1973) gives results of the chemical analysis of 45 water samples from the Central Plateau, showing a low concentration of ions with seawater dominance of ions prevailing; tables 1, 3, 4 and 5 of Buckney and Tyler (1973) give results of water sample analysis from areas, but not the exact locations, from which paracalliopes have been collected). Ionic concentration of the water appears to be a strong factor governing the distribution of these amphipods for, while individuals may tolerate wide ranges of salinities under experimental conditions, the breeding rate reaches an optimum (for paracalliopes collected from freshwater near Hobart) in 40% sea water (P.S. Lake, *pers. comm.* of class results). The largest brood size found in *P. larai* is 4 (see table 1). Paracalliopes carrying 16 - 20 embryos have been collected from streams just above the brackish water zone (D. Coleman, *pers. comm.*).

The species status of Tasmanian paracalliopes is currently being studied (D. Coleman, *pers. comm.*), to ascertain whether the same species is found in fresh and brackish water for example, or whether there are separate species each selecting a particular water salinity as in New Zealand: Barnard (1972b) lists *P. fluviatilis* from freshwater, *P. karitane* from brackish water and *P. novizealandiae* from marine environments. Nevertheless, there appears to be at least three freshwater species of *Paracalliope* in Tasmania, including one species associated with the yabby (*Parastacoides* spp.) burrows of western Tasmania. In New Zealand, *P. fluviatilis* is abundant in Lake Waikare (Chilton 1906) and 'may occur' in Lake Rotoiti (Barnard 1972a, p. 74). Paracalliopes from lacustrine habitats in Tasmania have so far been found only in Big Lake Waterhouse where they do not appear to be taxonomically distinct from paracalliopes in the nearby streams. None has yet been found in the eutrophic Lakes Dulverton and Tiberias. The genus *Paracalliope* previously recorded from Lake Edgar (Knott and Lake

TABLE 1

Sex	Length (mm) Range	Length (mm) Average	Breadth (mm) Range	Breadth (mm) Average	Antenna 1 Range	Antenna 1 Mode	Antenna 11 Range	Antenna 11 Mode	No. of eggs Range	No. of eggs Mode	Ratio, Length propodite / length dactylopodite
Male	1.15 - 1.60	1.30	0.44 - 0.68	0.56	4 - 12	9	7 - 13	10	0		1 - 1.40
	(20)		(20)		(20)	(7)	(19)	(7)			(19)
Female	0.81 - 1.13	0.99	0.49 - 0.64	0.56	4 - 8	6	5 - 9	7	1 - 4	3	1 - 1.42
	(20)		(20)		(20)	(10)	(20)	(9)	(20)		(12)

Length - measured from anterior limit of rostrum to the posterior limit of the peraeon, along mid dorsal line.

Breadth - measured across the width of peraeon segments 4 & 5, but excluding the bulge of the coxal side plates.

Antennae I & II - count of the number of flagellar segments in the right hand antennae; some variation does occur between the number of segments between the right and left hand sides.

Numbers in brackets refer to the frequency of observation.

TABLE 2

PATTERNS OF "RELATIVE LENGTH AND SPINE NO" OF THE 3 COMPONENTS OF THE UROPOD OF *P. larai*.

Peduncle = P; Inner Ramus = I; Outer Ramus = O; Lengths in mm.

Uropod	Sex	Pattern	Segment	Length No. of obs.	Length Range	Length Av.	Spine number Range	Spine number Mode (frequency)
1	Male	Three components subequal, but P > I > O	P	20	0.27 - 0.39	0.33	3-5	4 (13)
			I	20	0.26 - 0.35	0.30	1-3	2 (15)
			O	20	0.25 - 0.32	0.27	0-2	1 (15)
	Female	Three components subequal P ≥ I, both > O	P	20	0.15 - 0.24	0.21	2-4	3 (9); 4 (9)
			I	20	0.18 - 0.24	0.21	0-3	2 (14)
			O	19	0.12 - 0.22	0.19	0-2	2 (9)
II	Male	I longest segment P ≷ O	P	19	0.17 - 0.25	0.21	1-3	3 (10)
			I	20	0.27 - 0.35	0.30	1-3	2 (12)
			O	20	0.17 - 0.22	0.20	2-3	2 (19)
	Female	I > O > P	P	20	0.10 - 0.15	0.13	1-3	2 (12)
			I	20	0.15 - 0.24	0.21	1-3	3 (9)
			O	20	0.12 - 0.17	0.14	0-3	2 (15)
III	Male	Three components subequal P=O, both just longer than I	P	20	0.13 - 0.17	0.16	0-2	0 (16)
			I	20	0.13 - 0.17	0.16	0-2	2 (10)
			O	20	0.15 - 0.17	0.16	0-2	2 (9)
	Female	I just longer than P & O, P=O	P	20	0.07 - 0.12	0.10	0-1	0 (18)
			I	20	0.071 - 0.121	0.10	0-1	0 (18)
			O	20	0.07 - 0.12	0.10	1-2	1 (17)

1974) is now known to have been misidentified (D. Coleman, *pers. comm.*), the amphipods being in fact calliopids of another genus. Whether the paracalliopes from the marshes and creeks surrounding Lake Edgar have similarly been misidentified awaits further work.

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PHYTOSOCIOLOGICAL ANALYSIS OF THE VEGETATION OF LAGOON BEACH, TASMANIA

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(with two tables, four text-figures and four plates)

ABSTRACT

The vegetation of the Lagoon Beach area is mapped and described. Classification and ordination of thirty-five randomly located quadrats, and Chi^2 analysis of association between species, reveal three main species/stand groups. The wombat-grazed closed-herbfields dominated by *Samolus repens* and *Schoenus nitens* form one strong group associated with the lagoonal flats. A second group consists of stands which include characteristic heath species such as *Casuarina monilifera* and *Hypolaena fastigiata*. A third, less well-defined group consists mainly of *Eucalyptus viminalis* open forests with an understory characteristically dominated by *Pteridium esculentum*. The factors that could be responsible for the differentiation of the vegetation of the area are discussed, and a species list is appended.

INTRODUCTION

The clearing of Tasmanian native vegetation has accelerated over recent years, especially in coastal areas of relatively little relief. Yet, our knowledge of the ecology and floristics of those areas most prone to clearing is minimal. The north-western tip of the Tasman Peninsula is one area showing many signs of impending conversion to smiling pastures and uncontrolled shack development. At present (September 1974) the only parts of the area not privately owned are a narrow coastal reserve and the Saltwater River Scenic Reserve of 214 ha. Neither of these reserves include the heath or lagoon flat communities found in the area described in this article. The study area is located on the west coast of the Tasman Peninsula opposite Sloping Island (fig. 1).

No climatic data are available, but the mean annual rainfall at Lagoon Beach is probably approximately 650 mm, distributed reasonably evenly throughout the year, with the highest monthly totals being received in late autumn-early winter and spring. Frosts are almost certainly rare.

The area is underlain by Triassic sandstone which has been largely covered by sand sheets, dunes and lagoon deposits, but which outcrops in the cliffs in the north of the study area. The area includes two lagoons surrounded by flats which are separated by a slightly elevated sand sheet, and cut off from the sea by a retreating foredune. To both the north and the south of the lagoons and flats the land rises gently to approximately 30 m.

The soils found in the area are predominantly deep sands. The soils of the flats and foredune exhibit little horizon development apart from some surface darkening by organic matter. In the case of the flats this lack of horizonation probably has resulted from periodic inundation, and in the case of the foredune from the youth of the parent material. Elsewhere the soils are sand podzols with a well-developed and deep bleached horizon and a marked zone of concentration of iron and humus. The soils of the flats and seaward slopes of the foredune are neutral to slightly alkaline in reaction, while in the remainder of the study area the soils are acidic.

Phytosociological Analysis of Vegetation, Lagoon Beach

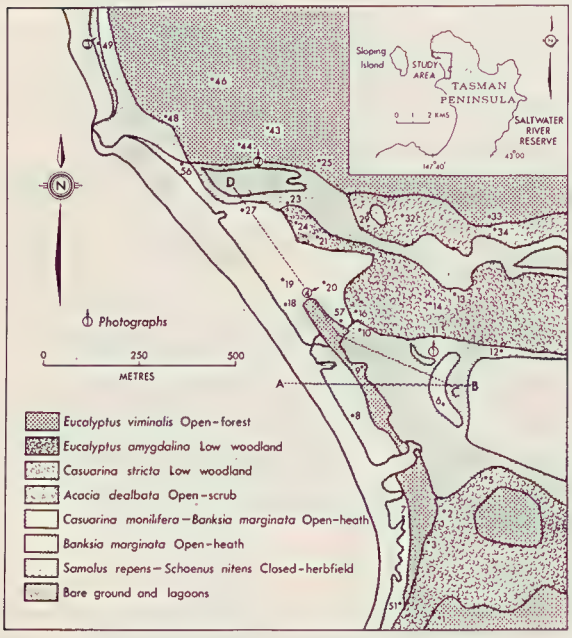

FIG. 1. - Vegetation and location map. The locations of sample areas, levelling traverses and photographs are shown.

METHODS

Thirty five sample areas were located randomly throughout the study area (fig. 1). All species with aerial organs above these 10 x 10 m squares were recorded and collected. The rooted frequency, density and coverage of each species occurring within ten one square m quadrats, located randomly within each sample area, were recorded. With species of rhizomatous habit, such as *Pteridium esculentum*, the number of unconnected aerial shoots rather than the actual number of plants was recorded. Coverage was estimated to the nearest ten percent. The coverage and density figures for the ten quadrats were averaged to give a sample area mean.

Species not found within the sample areas were collected in September 1972 when sampling took place and in December 1972. Specimens were identified where possible to the species level (Appendix). The vegetation of the area was mapped according to the structural classification of Specht (1970) from field data and aerial photograph analysis.

The dimensional relationships between all species occurring in seven or more sample areas were explored using uncorrected Chi^2 as a measure of association. The use of Yates correction in this context, even although cell values are low, would have resulted in a conservative estimate of association (Grizzle 1967).

In establishing stand relationships an importance value was calculated for each species in each stand from the frequency, coverage and density values. Relative values for each of the three abundance measures were calculated by totalling the absolute values for all species in a stand and expressing the contribution of each single species as a percentage. The importance value was derived from the addition of the relative frequency, relative coverage and relative density values, and the division of this total by three.

The stands were then classified using the Zurich-Montpellier technique (Bridgewater 1971). However, the groups recognized through the use of this technique have not been formally named, as data from such a small area are almost certainly insufficient to make taxonomic decisions.

Stand relationships were further analyzed using the polar ordination technique of Bray and Curtis (1957). This technique has been shown to be more suitable for phytosociological data than the currently more fashionable principal components analysis (Gauch and Whittaker 1972). The polar stands for the x axis were selected on the basis of soil drainage conditions and distance values. The poles for the y axis were selected to give a contrast in exposure to salt spray, and on the basis of distance values.

RESULTS AND DISCUSSION

Structural Variation

The structure of the vegetation of the study area is mapped in figure 1. Structural boundaries are generally relatively sharp, especially that between the herbfield and other structural units (plates 1 and 2). However, the boundaries between open-heath, low woodland and open-forest are best considered ecotones whose width is greater than the "to scale" width of the lines dividing them on the map. The dominant species within each unit are indicated in the map key.

PLATE 1. - The closed-herbfield with the emergent shrub zone in the middleground and low woodland in the background.

PLATE 2. - The boundary between the closed-herbfield and open-forest. Note the density of wombat scats in the foreground and of *Pteridium esculentum* in the background.

Species Relationships

The dimensional relationships diagram (fig. 2) reveals three major groups of species. The small group at the base of the diagram consists of the three species included from the herbfield. These species are linked through *Epacris lanuginosa* and *Bossiaea prostrata* to the group of species found predominantly in the heath and woodland. *E. lanuginosa* and *Leptospermum scoparium* are logically located in an intermediate position as they tend to be found in the wetter heaths adjacent to the herbfield. The strong group of heath species has a number of links to the more diffuse group of species characteristic of the open-scrub and open-forest.

Stand Relationships

The sample areas divide into two major groups, on the basis of their floristic composition. The first and smaller group is characterized by the presence of *Samolus repens, Schoenus nitens, Pultenaea dentata, Leptospermum scoparium* and *Gnaphalium candidissimum* (table 1). Only two of the sample areas in this group (10 and 12) are located entirely on the lagoonal flat closed-herbfield, but the others are located marginally to this structural type.

The most constant species of the second group are *Pteridium esculentum, Banksia marginata, Aotus ericoides, Haloragis tetragyna* and *Hibbertia fasciculata* (table 2). However, of these species only *Pteridium esculentum* and *Haloragis tetragyna* are reasonably faithful. Three subgroups of sample areas can be recognized within the second group (table 2). The strongest subgroup is characterized by *Hypolaena fastigiata, Cassytha glabella, Eucalyptus amygdalina, Dillwynia glaberrima, Lepidosperma concavum* and *Stylidium graminifolium*, the same group of species strongly interlinked in figure 3. Similarly, the open-scrub and open-forest group of species evident in figure 3 characterize another less well-defined group of sample areas. These species

are *Eucalyptus viminalis, Kennedia prostrata, Hibbertia acicularis, Lomandra longifolia, Goodenia lanata* and *Acacia dealbata*. The third subgroup of sample areas is characterized by the general absence of the species which characterize the first two subgroups.

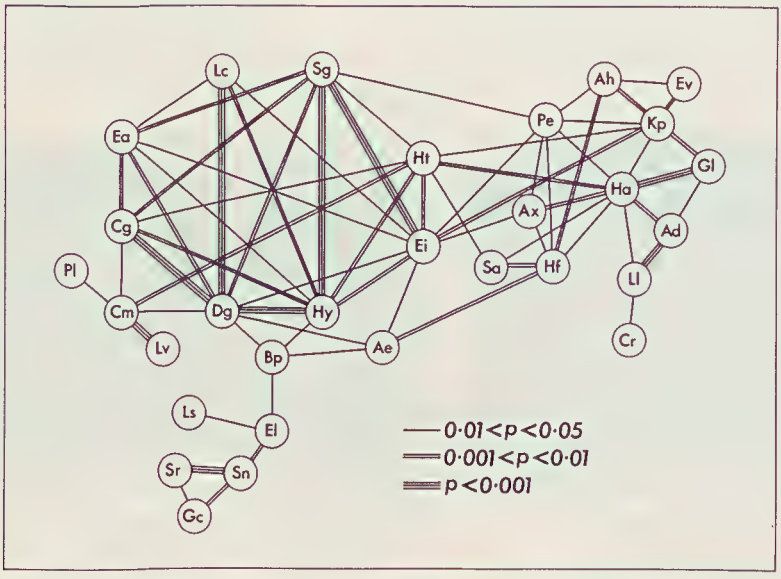

FIG. 2. - The dimensional relationships of species occurring in seven or more sample areas.
Ad = *Acacia dealbata*, Ae = *Aotus ericoides*, Ah = *Astroloma humifusum*, Ax = *Amperea xiphoclada*, Bp = *Bossiaea prostrata*, Cg = *Cassytha glabella*, Cm = *Casuarina monilifera*, Cr = *Carpobrotus rossii*, Dg = *Dillwynia glaberrima*, Ea = *Eucalyptus amygdalina*, Ei = *Epacris impressa*, El = *Epacris lanuginosa*, Ev = *Eucalyptus viminalis*, Gc = *Gnaphalium candidissimum*, Gl = *Goodenia lanata*, Ha = *Hibbertia acicularis*, Hf = *Hibbertia fasciculata*, Ht = *Haloragis tetragyna*, Hy = *Hypolaena fastigiata*, Kp = *Kennedia prostrata*, Lc = *Lepidosperma concavum*, Ll = *Lomandra longifolia*, Ls = *Leptospermum scoparium*, Lv = *Leucopogon virgatus*, Pe = *Pteridium esculentum*, Pl = *Pimelea linifolia*, Sa = *Styphelia adscendens*, Sg = *Stylidium graminifolium*, Sn = *Schoenus nitens*, Sr = *Samolus repens*.

Continuous variation between stands is evidenced by the results of polar ordination (fig. 3). The sample areas in the first group are located contiguously, but there is no marked break between this group and the second group. The sample areas in the subgroups of the second group are not located entirely contiguously, probably because the species whose presence or absence define these subgroups do not generally account for much of the total relative importance values for the sample areas. Several stands that were neither similar in their floristic composition to each other nor to the two major groups were excluded from the tables, but their locations are shown on the ordination (fig. 3).

Environmental Relationships

Although the primary objective of the study was to describe the vegetation of the area, observations were also made on vegetation-environment relationships. The major factors that seem important in differentiating the vegetation of the area are soil drainage conditions, soil fertility, the influence of saltspray, and grazing. These factors will be discussed in relation to the lagoonal flats, and the remainder of the study area.

Four zones can be distinguished in the lagoonal flats. *Triglochlin procera* and *Villarsia reniformis* form the first zone, which is separated from the third zone by a bare area. The third zone is the closed-herbfield, usually only one or two cm high, and closely resembling a bowling green (plate 1). In the fourth zone scattered individuals of *Pultenaea dentata* and *Leptospermum scoparium* are found emerging from the dense sward of herbs (plate 1). Water relations may control most of the variation in

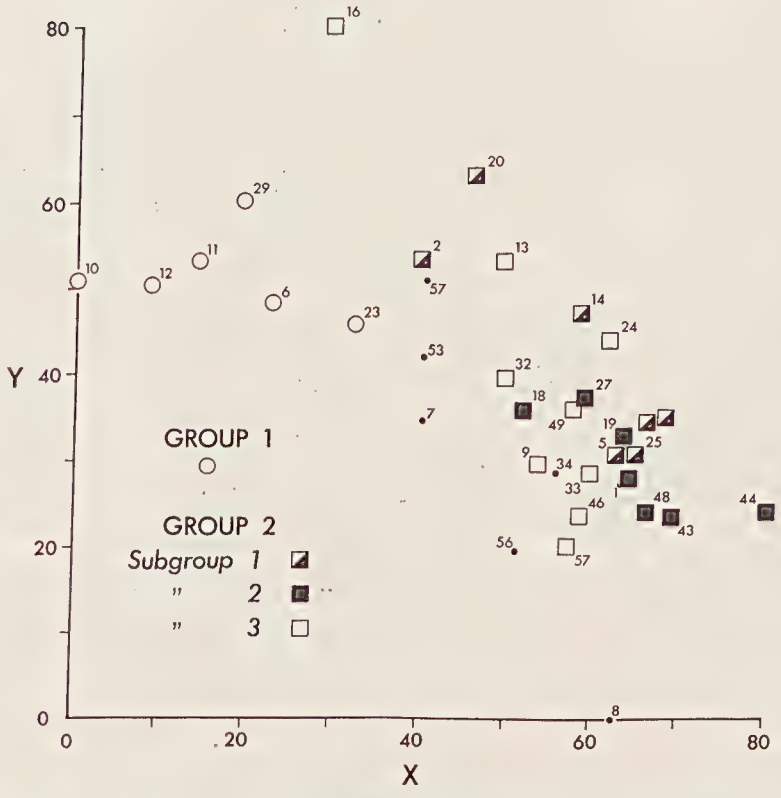

FIG. 3. - Ordination of the sample areas showing classificatory groups (tables 1 and 2).

the vegetation of the lagoon and lagoon flat habitats. The first zone occurs in a semiaquatic habitat where plant roots are probably almost permanently waterlogged. The bare zone may be the result of frequent alternation of inundation and exposure. One of the effects of this alternation may be the accumulation of salt in the soils of this zone during exposure periods, as the waters of the lagoons are brackish. The third and fourth zones may be inundated only rarely, but the watertable is probably always close enough to the surface to allow plants ready access to moisture. The main evidence for periodic inundation of the closed-herbfield is the nature of the soils. They are neutral to slightly alkaline in reaction, indicating perhaps an accumulation of salt as a result of occasional inundation with brackish water, and they lack horizonation, which may indicate either youth or prevention of sustained leaching through periodic inundation. The relationships between topography, watertable depth and vegetation across two dumpy-levelled transects in the study area are shown in figure 4. The watertable depths are those found in September 1972 after a relatively dry winter.

Although drainage and watertable conditions are probably most important in determining the boundary between the closed-herbfield and other communities, intensive grazing by wombats may play a strong part in maintaining the structure of the vegetation and preventing shrub invasion. The density of wombat scats on the herbfield can be gauged from plate 2. Dramatic changes in the structure and species composition of

Phytosociological Analysis of Vegetation, Lagoon Beach

TABLE 1

RELATIVE IMPORTANCE VALUES

Sample area	10	12	11	6	23	29	%I*
Samolus repens	28	21	25	24	13	33	85
Schoenus nitens	25	38	32	-	10	18	90
Pultenaea dentata	7	5	14	2	1	-	100
Leptospermum scoparium	-	3	9	6	3	12	34
Gnaphalium candidissimum	6	4	3	1	13	-	42
Hydrocotyle hirta	22	1	-	17	-	-	91
Cotula reptans	1	26	-	11	-	-	97
Haloragis micrantha	1	1	1	-	-	-	100
Acacia verticillata	-	1	-	9	1	-	23
Hibbertia fasciculata	-	-	2	2	15	-	10
Banksia marginata	1	-	-	11	3	5	9
Aotus ericoides	-	-	2	5	16	-	18
Epacris lanuginosa	-	-	5	-	1	17	27

TABLE 2
(continued from opposite page)

Additional Species: *Acaena anserinifolia* (6), *Acacia dealbata* (12), *Astroloma humifusum* (6, 23), *Billardiera longiflora* (29), *Bossiaea cinerea* (11), *Carpobrotus rossii* (6, 23), *Casuarina monilifera* (23), *Centrolepis fascicularis* (10, 23), *Daviesia ulicifolia* (12), *Dichondra repens* (10), *Eucalyptus amygdalina* (11, 23), *E. ovata* (23, 29), *E. viminalis* (11), *Hakea teretifolia* (29), *Haloragis tetragyna* (11), *Hypochaeris glabra* (10, 12), *Kennedia prostrata* (6), *Lepidosperma longitudinale* (6), *L. concavum* (29), *Leucopogon ericoides* (23), *L. virgatus* (23), *Melaleuca squarrosa* (29), *Persoonia juniperina* (29), *Pimelea linifolia* (29), *Pteridium esculentum* (6, 23), *Scaevola hookeri* (29), *Scirpus nodosus* (6), *Sprengelia incarnata* (29), *Styphelia adscendens* (23, 29).

* Total relative importance values in table/total relative importance values for all sample areas x $\frac{100}{1}$.

TABLE 2
RELATIVE IMPORTANCE VALUES

Sample Area	43	48	44	1	19	27	18	33	49	9	46	3	2	21	25	14	20	5	13	32	24	16	51	%1*
Banksia marginata	1	1	-	8	12	15	22	1	7	7	12	3	1	2	1	-	1	7	20	16	6	2	8	66
Pteridium esculentum	36	49	26	32	32	15	8	30	12	20	44	13	5	21	27	16	-	20	4	21	23	-	61	84
Aotus ericoides	3	1	8	-	6	-	5	-	-	1	1	8	5	16	7	6	3	15	1	-	5	1	4	73
Haloragis tetragyna	2	2	4	18	2	8	-	1	2	-	-	6	1	5	7	5	3	11	7	2	3	4	-	99
Hibbertia fasciculata	3	11	3	-	5	18	1	2	36	9	7	6	9	4	1	10	7	2	1	-	10	-	-	74
Casuarina monilifera	-	-	-	1	11	2	9	-	-	1	-	-	26	11	7	28	25	1	15	13	18	23	-	98
Leucopogon virgatus	-	-	-	-	14	5	2	4	-	2	-	-	12	-	1	3	-	-	-	1	17	11	-	97
Amperea xiphoclada	2	8	3	-	1	6	12	-	4	2	1	1	-	6	2	4	3	4	-	-	1	1	6	99
Astroloma humifusum	-	2	2	6	-	8	-	1	7	-	5	1	-	1	-	-	-	-	8	-	-	-	-	59
Eucalyptus viminalis	4	1	3	1	-	-	-	5	-	1	1	-	-	-	-	-	-	3	3	-	-	-	-	88
Kennedia prostrata	1	2	3	3	-	-	-	2	1	2	-	4	-	1	1	-	-	-	-	-	-	-	-	95
Hibbertia acicularis	3	8	6	7	1	3	1	-	6	-	-	2	-	-	-	1	-	-	-	-	5	-	-	100
Lomandra longifolia	1	-	2	-	4	2	1	-	1	1	1	-	-	-	-	-	-	-	4	-	-	-	-	81
Goodenia lanata	1	1	6	7	2	-	4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	100
Acacia dealbata	2	-	4	1	6	3	-	-	6	-	-	-	-	-	-	-	-	-	-	1	-	-	-	54
Bossiaea cinerea	3	-	-	-	-	1	4	6	-	-	-	-	-	-	5	-	-	-	1	1	-	-	8	94
Viola hederacea	2	8	4	-	-	-	-	-	-	-	21	1	-	-	-	-	-	-	-	-	-	-	-	100
Epacris impressa	7	1	14	-	-	-	-	1	-	-	-	20	10	13	7	1	-	4	-	-	3	-	1	100
Hypolaena fastigiata	-	-	-	-	-	-	-	-	-	-	-	7	10	1	2	2	4	-	-	1	-	4	-	100
Cassytha glabella	-	-	-	-	-	-	-	-	1	-	-	-	3	1	3	3	13	1	-	6	-	-	-	97
Eucalyptus amygdalina	-	-	-	-	-	-	-	-	-	-	-	4	1	9	1	1	-	1	-	8	-	-	-	89
Dillwynia glaberrima	-	-	-	-	-	-	-	-	-	3	-	2	14	4	1	3	3	16	-	-	-	-	-	77
Lepidosperma concavum	-	-	1	-	-	-	-	-	-	29	-	7	7	3	4	3	4	-	9	-	-	-	5	99
Stylidium graminifolium	-	-	-	-	-	-	-	2	1	-	-	5	1	2	5	8	-	4	-	-	5	-	-	79
Gompholobium huegelii	2	-	1	-	-	-	-	-	-	-	-	1	-	-	-	1	2	-	-	-	-	2	-	100
Pimelea linifolia	-	-	1	1	-	3	3	-	-	-	4	-	1	1	-	-	2	1	-	-	-	1	-	95
Styphelia adscendens	4	1	1	-	2	1	-	-	1	-	-	1	1	-	-	-	-	1	1	-	1	-	-	71
Leucopogon ericoides	4	-	-	-	-	-	-	1	-	-	-	-	-	-	11	-	-	-	-	-	5	-	-	95
Lepidosperma longitudinale	-	-	-	-	-	8	10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	49
Carpobrotus rossii	-	-	-	-	4	6	11	-	1	23	-	-	-	-	-	-	-	-	-	-	-	4	-	28
Oxalis corniculata	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	100
Bossiaea prostrata	-	-	-	-	1	-	-	-	-	-	-	1	-	-	1	-	2	-	5	-	-	3	-	93
Epacris lanuginosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	14	-	7	-	-	19	-	50
Leptospermum scoparium	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	8	9	-	-	-	-	21
Melaleuca squarrosa	1	-	7	-	-	-	-	4	3	-	-	-	-	-	-	-	-	-	-	4	-	-	-	39
Leptospermum glaucescens	1	-	-	-	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-	-	-	-	-	100
Samolus repens	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	20	-	14
Schoenus nitens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	1	-	9	-	10
Acaena anserinifolia	1	4	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	4	85

the lagoonal flats vegetation could be expected with the removal of this grazing pressure. Such changes are recorded for English dune slack communities as a result of reduction of grazing by rabbits (Ranwell 1960). The lagoon flat closed-herbfield is similar in environmental conditions and species composition to dune slack communities found elsewhere in Tasmania (e.g. Bowden and Kirkpatrick 1974), although the Lagoon Beach closed-herbfields may be the largest area of this vegetation type in Tasmania.

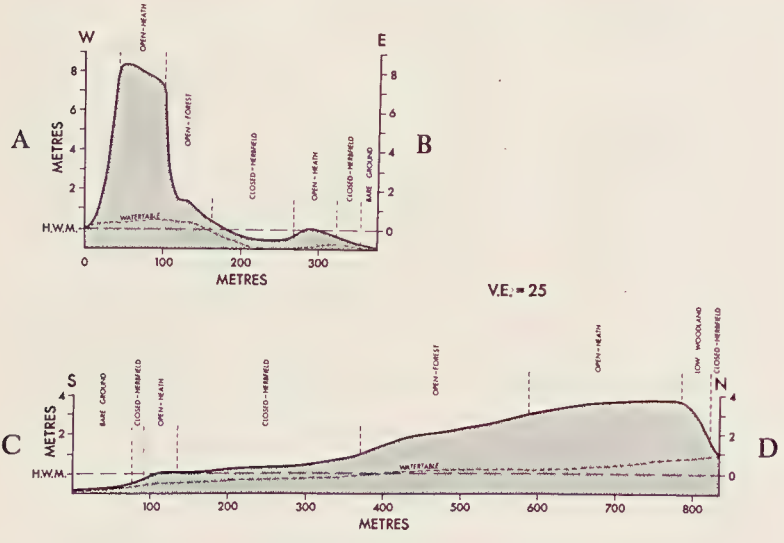

FIG. 4. - Results of the levelling traverses.

Other factors that could be related to the occurrence of the closed-herbfield are salinity and nutrient availability. There could be movement of nutrients in the groundwater from surrounding areas into the flats. The nutrients would tend to remain in the soils of the flats in the absence of sustained leaching. The salinity of the soils of the flats, evidenced by the abundance of such species as *Samolus repens* and *Selliera radicans*, may prevent invasion by species adapted to waterlogging, but unable to withstand moderate salinity. A detailed study of these closed-herbfields could be most rewarding, especially as our knowledge of the ecology of the vegetation of the slack habitat type is somewhat scant (Ranwell 1972).

Outside the lagoonal flats edaphic conditions seem to be the most important influence on vegetation. The open-heath and low woodland communities are found where there is a considerable depth of heavily leached sand overlying the bedrock, whereas the open-forest and open-scrub communities occur where the bedrock could be expected to be relatively close to the soil surface or where leaching of deep sands has not been severe, as in the patches of open-forest on the lee slopes of the foredune (fig.1). However, open-heath does occur on the young soils of the foredune, where exposure to saltspray and relative lack of moisture may be the major controlling factors. Also, low woodland occurs on the clifftops in the north of the study area (fig. 1) where the bedrock is close to the surface. However, in contrast to the other areas of low woodland, the community is dominated by *Casuarina stricta* (plate 3), a species whose resistance to the effects of saltspray often give it dominance of a narrow coastal strip, especially where soils have formed *in situ*.

The occurrence of low woodland may be partially controlled by water relations. It tends to occur in areas of low relief and altitude, and varies internally according to topographic position. In the most ill-drained parts of the low woodland species such as *Eucalyptus ovata* and *Melaleuca squarrosa* are common, while in the better drained areas *Eucalyptus amygdalina* is dominant, and the subordinate species are those typical of dry heaths. The open heath-low woodland boundary may be partially controlled

PLATE 3. - Pruned coastal shrubs on sand and *Casuarina stricta* low woodland on clifftop soils formed *in situ* on sandstone.

PLATE 4. - Open-heath with low woodland in the middleground and open-forest in the background.

by water relations, with the open-heath generally being found at higher elevation than the low woodland. The influence of saltspray and soil fertility related to the depth of sand may also be important. The most extensive area of open-heath occurs where the altitudinal difference between the top of the foredune and the land to its lee is smallest. Asymmetry of form, possibly due to sodium chloride necrosis, is evident in the trees on the open heath-low woodland interface (plate 4). Some of the areas mapped as open-heath (fig. 1) are floristically better considered part of the lagoon flat vegetation. The dominant species are *Banksia marginata* and *Acacia verticillata* with the species of the ground stratum being those found abundantly on the flats. This type of open-heath occurs on similar soils to the closed-herbfield, but is found in slightly more elevated positions.

The open scrub-open forest boundary is probably the result of firing and saltspray. *Eucalyptus viminalis*, the dominant of the open-forest, has regenerated in the open-scrub among dead trees of the same species. A fire may have removed the protection given to these now dead eucalypts by vegetation closer to the coast, and epicormic shoots may have been subject to sufficient sodium chloride necrosis to prevent recovery. However, seedlings have been able to establish in the shelter of the regenerating understory, and eventually, if no more fires ensue, the open-scrub could revert to open-forest.

ACKNOWLEDGEMENTS

The 1972 Geography III class at the University of Tasmania collected the quadrat data. Mrs. J. Townrow, Miss Jean Jarman and Professor W.D. Jackson aided in the identification of plant specimens, and Mr. G. Van der Geer drew the figures.

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APPENDIX

Species collected from Lagoon Beach

Nomenclature follows Churchill and de Corona (1972) except where authorities are given. Introduced species are marked with a cross.

DENNSTAEDTIACEAE: *Pteridium esculentum.*
JUNCAGINACEAE: *Triglochin procera.*
GRAMINEAE: *Agrostis ?avenacea, +Ammophila arenaria, Danthonia setacea, Deyeuxia ?quadriseta, Dichelachne rara* R. Br., *Stipa mollis* R. Br., *Tetrarrhena distichophylla, +Vulpia bromoides.*
CYPERACEAE: *Lepidosperma concavum, L. filiforme, L. longitudinale, Schoenus nitens, S. tenuissimus, Scirpus nodosus.*
RESTIONACEAE: *Leptocarpus tenax, Hypolaena fastigiata.*
CENTROLEPIDACEAE: *Centrolepis fascicularis.*
LILIACEAE: *Dianella revoluta, Lomandra longifolia.*
ORCHIDACEAE: Spp.
CASUARINACEAE: *Casuarina littoralis, C. monilifera, C. stricta.*
PROTEACEAE: *Banksia marginata, Hakea teretifolia, Persoonia juniperina.*
SANTALACEAE: *Exocarpos strictus.*
AIZOACEAE: *Carpobrotus rossii.*
CARYOPHYLLACEAE: *Scleranthus biflorus.*
LAURACEAE: *Cassytha glabella.*
TREMANDRACEAE: *Tetratheca pilosa.*
PITTOSPORACEAE: *Billardiera longiflora.*
ROSACEAE: *Acaena anserinifolia.*
MIMOSACEAE: *Acacia dealbata, A. melanoxylon, A. suaveolens, A. verticillata.*
PAPILIONACEAE: *Aotus ericoides, Bossiaea cinerea, B. prostrata, Daviesia ulicifolia, Dillwynia glaberrima, Gompholobium huegelii, Kennedia prostrata, Pultenaea daphnoides, P. dentata, Sphaerolobium vimineum.*
GERANIACEAE: *Pelargonium australe.*
OXALIDACEAE: *Oxalis corniculata.*
RUTACEAE: *Correa alba.*
POLYGALACEAE: *Comesperma calymega, C. volubile.*
EUPHORBIACEAE: *Amperea xiphoclada.*
RHAMNACEAE: *Pomaderris elliptica* Labill.

DILLENIACEAE: *Hibbertia acicularis, H. fasciculata.*
HYPERICACEAE: *Hypericum gramineum.*
VIOLACEAE: *Viola hederacea.*
THYMELACEAE: *Pimelea humilis, P. linifolia.*
MYRTACEAE: *Eucalyptus amygdalina* Labill., *E. ovata, E. viminalis, Leptospermum glaucescens, L. scoparium, Melaleuca squarrosa.*
HALORAGACEAE: *Haloragis micrantha, H. tetragyna, H. teucrioides.*
UMBELLIFERAE: *Hydrocotyle hirta.*
EPACRIDACEAE: *Astroloma humifusum, Epacris impressa, E. lanuginosa, Leucopogon ericoides, L. parviflorus, L. virgatus, Sprengelia incarnata, Styphelia adscendens.*
PRIMULACEAE: *Samolus repens.*
MENYANTHACEAE: *Villarsia reniformis.*
CONVOLVULACEAE: *Dichondra repens.*
MYOPORACEAE: *Myoporum insulare.*
PLANTAGINACEAE: *+Plantago coronopus.*
CAMPANULACEAE: *Wahlenbergia ?tadgellii.*
LOBELIACEAE: *Pratia pedunculata.*
GOODENIACEAE: *Goodenia lanata, Scaevola hookeri, Selliera radicans.*
STYLIDIACEAE: *Stylidium graminifolium.*
COMPOSITAE: *Brachycome aculeata, Cassinia aculeata, Cotula coronopifolia, C. reptans, Craspedia glauca, +Gnaphalium candidissimum, Helichrysum scorpioides, +Hypochaeris glabra, +H. radicata, Lagenophora stipitata, +Leontodon taraxacoides, Senecio biserratus, S. minimus, +Sonchus asper, S. megalocarpus.*

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THE ESTABLISHMENT OF *SPARTINA* IN THE TAMAR ESTUARY, TASMANIA

by Ada W. Phillips

Department of Environmental Sciences, University of Lancaster, England

(with five text-figures)

ABSTRACT

Spartina anglica was introduced into the Tamar Estuary, Tasmania, in 1947. Initially spread was slow but subsequently rapid. It is capable of colonizing all rock types and sediments available in the estuary but fine sediments provide the most and basalt the least suitable substrate. It colonises all available slopes (1^{o}-28^{o}).

As a result of the introduction, mud banks become stabilized and the navigable channel thereby safeguarded. The spread of *Spartina* has, however, adversely affected some beaches and private jetties. (Ed.).

INTRODUCTION

The grass *Spartina* was introduced to the Tamar Estuary in 1947 in a limited area of the inter-tidal mud flats at Windermere (see figure 1). By the summer of 1971/72 the *Spartina* had spread so rapidly that many acres of mud flats had been or were in the process of being colonized along the 18 mile (29 km) stretch of the estuary from Dilston and Dog Point at the upstream end to East Arm and Ruffins Bay downstream. The aim of this study is to examine in detail the spread and present distribution of *Spartina* relating these to geological and sedimentological variations, degree of slope of the surface of the intertidal zone and position relative to high and low water marks. The overall effect on the estuary will finally be considered.

THE TAMAR ESTUARY

The 38 mile (61 km) long Tamar Estuary extending from Launceston to Low Head is the major navigable waterway on the north coast of Tasmania. Its present form was determined by a rise in sea level which drowned the pre-existing river valley. The Tamar is characterized by having a very winding course which varies markedly in width from about 1,000 feet (305 m) at Batman Bridge to several miles/kms where there are extensive bays and "arms". There is one major navigable channel, with banks of fine sediment on either side except where the estuary is constricted. In the bays and "arms" the mud banks cover many acres. The estuary experiences a diurnal tidal regime as defined by the British Admiralty, but with clearly defined semi-diurnal components giving an approximately six hour flood tide and seven hour ebb. At Launceston the tidal range on spring tides is up to 14 feet (4.28 m) and on neaps down to 9 feet (2.75 m); at the mouth of the Tamar it is up to 8 feet (2.45 m) on springs and down to 6 feet (1.83 m) on neaps.

Prior to the introduction of *Spartina* the intertidal areas of the estuary were almost completely bare of vegetation. Only the alga *Enteromorpha* was present extensively. In the innermost parts of the bays and "arms" near high water mark limited areas of salt marsh had developed covered with *Salicornia australis* as the main primary colonizer and with the back of the marsh dominated by *Phragmites*, *Juncus* and *Gahnia*.

SPARTINA in the Tamar Estuary

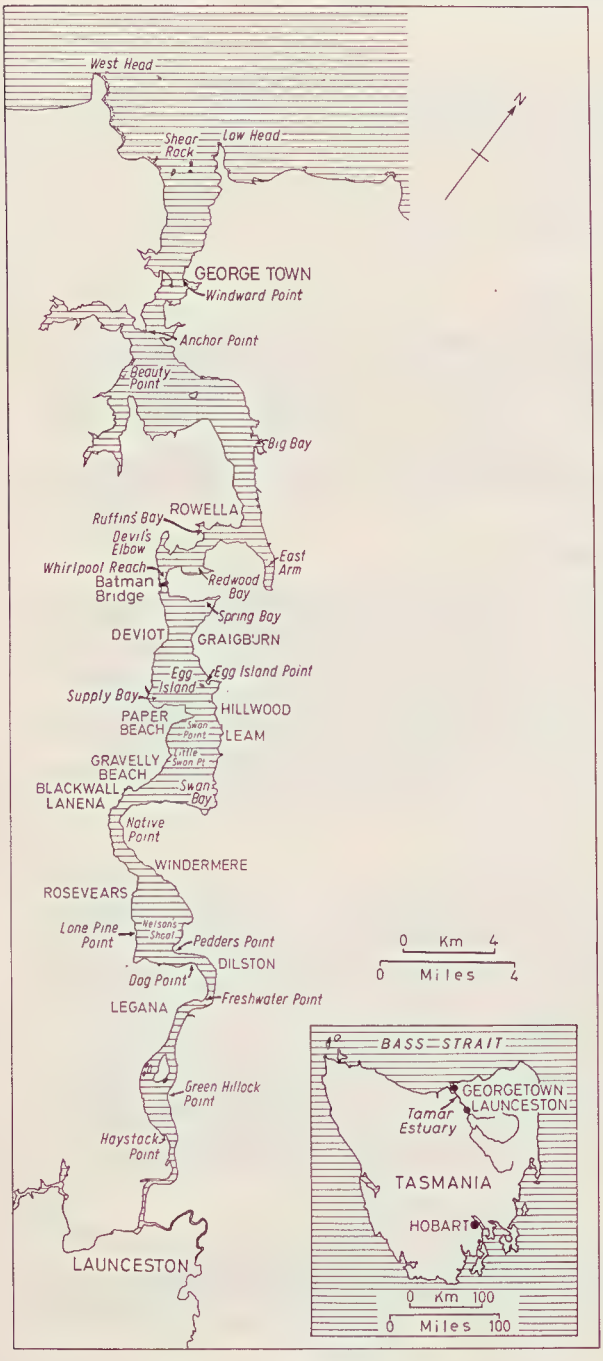


FIG. 1. - Locality Map.

INTRODUCTION OF *SPARTINA*

In 1947 the Department of Agriculture at Launceston planted *Spartina* on the mud banks at Windermere on behalf of the Port of Launceston Authority. The aim of this was to stabilize the banks. It was thought that the navigation channel off Rosevears and opposite Windermere could be safeguarded from considerable siltation if *Spartina* colonized the extensive shoals on the eastern side, which were subject to severe erosion during the combination of flood tide and north-west wind. After the initial plantings in 1947 a few more were made around them during the next three years. In 1955 a further acre (4,047 m^2) was planted with a 6 to 8 feet (1.83 - 2.45 m) interval between the plants and by 1962 these had spread and merged to give a continuous cover. During the early 1960's *Spartina* appeared rapidly in many places. Seeding was proved by the Department of Agriculture who measured a 15% germination rate, but the spread was probably due also to the distribution by the tidal streams of broken fragments which rooted easily.

The Department of Agriculture obtained the original *Spartina* plants from the Waite Agriculture Research Institute of the University of Adelaide and it is probable that these were derived from plants sent to South Australia from England. The British Nature Conservancy's Coastal Research Station has records of *Spartina townsendii* being despatched from East Anglia and Dorset to various individuals in south-eastern Australia although not specifically to the Waite Institute. It is very probable therefore that the species introduced was *Spartina townsendii* although whether it was the fertile hybrid or infertile hybrid is purely a matter for conjecture. It may be argued that the slow growth and lack of rapid spreading in the late 1940's and early 1950's indicated that the initial introduction was of the infertile hybrid and that either the

TABLE 1

AERIAL SURVEYS OF THE TAMAR ESTUARY

Date	Aerial Survey	Area of Estuary Covered	Remarks
27. 3.52	Project 1259 Scale 1:23,760	Dog Pt./Dilston-Deviot/Egg Is. except east shore Swan Bay - Leam	Almost H.W. conditions but with small areas of salt marsh exposed.
31. 1.56	1349 1:35,640(x2)	Launceston - Swan Pt./Egg Is.	Shores and mud banks clearly exposed.
24. 3.61	1301 1:35,640(x2)	Rosevears/Windermere - Tamar mouth	Mud banks close to shores exposed.
22. 1.63	1002 1:51,480	Rosevears/Windermere - Rowella/ East Arm	Mud banks very close to shores exposed.
2. 3.68	1696 1:31,680	Tamar Is. - Supply Bay/Hillwood except west shore Rosevears - Blackwall	Shores and adjacent mud banks clearly exposed.
6. 3.69	0017 1:9,504	Dilston and Freshwater Pt.	Almost H.W. conditions, but salt marsh exposed.
6. 3.69	0063 1:6,336	Lanena	" "
6. 3.69	0065 1:6,336	Blackwall	" "
6. 3.69	0066 1:6,336	Gravelly Beach	" "
6. 3.69	0067 1:6,336	Paper Beach	" "
6. 3.69	0018 1:6,336	Whirlpool Reach	" "
15.12.69	F115 1:31,680	Whirlpool Reach - Ruffins Bay/ Redwood Bay	Shores and mud banks well exposed.
16.12.69	F113 1:31,680	Tamar Is. - Paper Beach/Egg Is. except west shore at Blackwall	" "
5. 2.70	F102 1:11,088	Lanena	Shores and adjacent mud banks exposed.
16. 4.70	F177(colour) 1:15,840	Spring Bay - Ruffins Bay	Shores and adjacent mud banks well exposed.

1955 plantings were of the fertile hybrid or the infertile hybrid developed into the fertile hybrid during the late 1950's, when the rapid spread began to take place. The seeding proved in the early 1960's indicates that the dominant species then was the fertile hybrid, renamed in 1968 *Spartina anglica* (Hubbard).

SPREAD OF *SPARTINA* AS SHOWN BY AERIAL SURVEYS

Between 1947 and 1970 a series of vertical aerial surveys of parts of the Tamar Estuary was made on behalf of the Lands and Surveys Department and provides a record of the spread of *Spartina*. Table 1 gives the dates, project numbers, scales and areas of the surveys and notes on the tidal conditions. All the surveys were made during the summer months between December and March and records of seven summers are provided.

For *Spartina* to be recognisable from black and white air photographs within the range of scales listed a dense growth either in closely spaced clumps or in a continuous sward is necessary. It should be noted therefore that the following description is concerned only with such areas of dense growth and does not exclude the possible existence in addition of scattered clumps and isolated shoots.

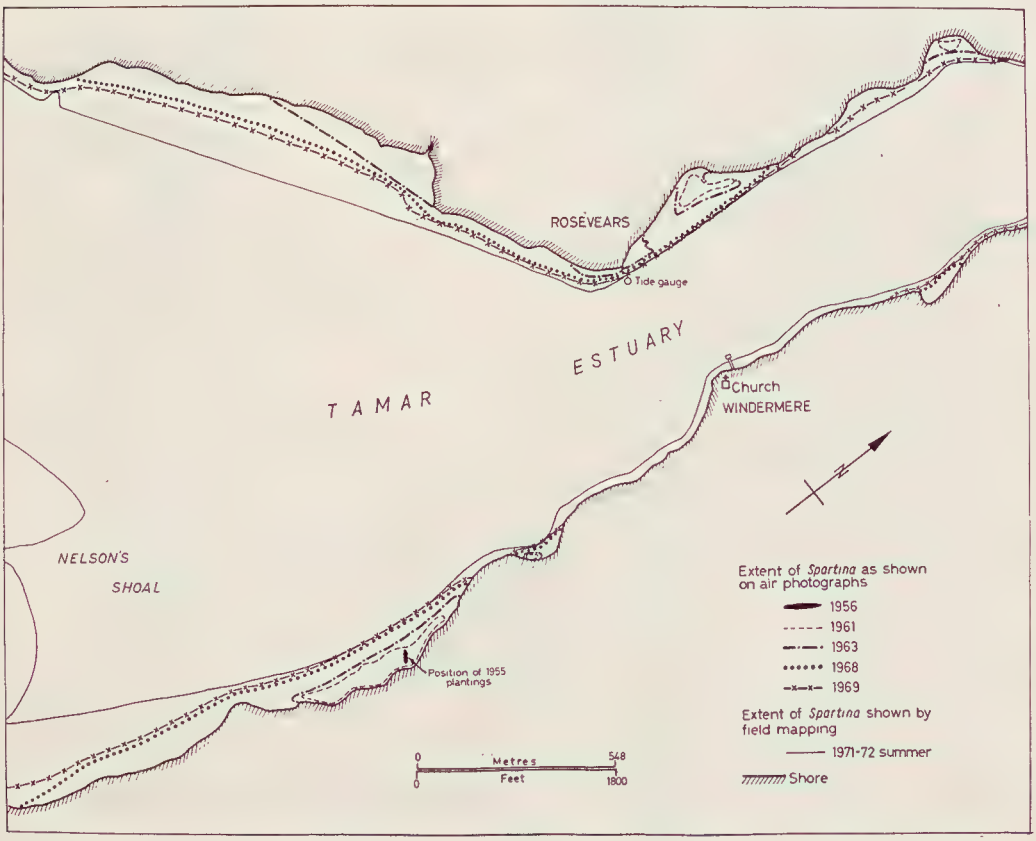


FIG. 2. - Extent of *Spartina*.

The survey of March 1952 fails to show the presence of any *Spartina* although presumably some of the plantings made between 1947 and 1950 at Windermere did survive. The following survey of January 1956 clearly reveals the acre planting at Windermere, made in 1955, but no other areas of growth are shown. The surveys from then onwards however reveal the rapid spread of *Spartina* throughout the whole central section of the estuary. Figure 2 is a plot of the spread in the Windermere and Rosevears areas.

By March 1961 the *Spartina* had spread from the acre (4,047 m^2) planting at Windermere to fill the central section of the embayment where it had been introduced and had appeared in an adjacent embayment. It had also become well established on the west shore of the estuary at Rosevears and Lanena, in sheltered embayments. By the time of the January 1963 survey, in addition to spreading around the previously established growths, it had appeared along further sections of the Rosevears shore and downstream from Native Point on the east shore. During the five years between this survey and that of March 1968 a considerable expansion occurred. By the latter date there was a continuous *Spartina* growth along much of the Windermere and Rosevears shores infilling the embayments and forming a narrow fringe around the small promontories. Upstream, the Legana shore and that around Pedders Point from Dilston almost to Windermere were continuously fringed with *Spartina*. Downstream, embayments between Native Point and Swan Bay and the shore at Gravelly Beach had been colonized.

From the six large scale aerial surveys carried out in March 1969 of limited parts of the Tamar Estuary the extension along the Dilston shore, the west shore between Lanena and Little Swan Point and around Swan Point can be traced. During the summer of 1969/70 four aerial surveys were carried out covering most of the central section of the estuary. They reveal an almost continuous fringe of *Spartina* on the east shore from Dilston to Swan Bay and on the west shore from Dog Point to around Swan Point, interrupted by only short sections where it was absent. In addition, on the east shore *Spartina* was starting to colonize the embayment upstream of Egg Island Point and Spring Bay. The rapid expansion of *Spartina* off Pedders Point on Nelson Shoal is particularly noteworthy at this time.

EXTENT OF *SPARTINA* DURING 1971/72 SUMMER

The distribution of *Spartina* was mapped in the field during the summer of 1971/72 and figure 3 shows the overall pattern. Maps showing the detailed distribution, plotted at a scale of 600 feet:1 inch (1:7,200) are held by the Port of Launceston Authority. For the purposes of field mapping, the *Spartina* was subdivided into areas of continuous sward, separate clumps and isolated shoots.

Not unexpectedly, the sections of shore where an almost continuous fringe of *Spartina* had been shown on the 1969/70 air photographs, by the summer of 1971/72 supported the major areas of continuous sward. The previously short bare sections within this had been colonized by separate clumps and clumps were also extending the continuous sward channelwards in many places. The expansion of *Spartina* on Nelson Shoal had continued at a rapid rate between 1969/70 and 1971/72 to give the most extensive area of continuous sward in the estuary, fringed with a zone of clumps channelwards. Downstream from Swan Point and Swan Bay *Spartina* had extended markedly. Areas of continuous sward were there limited to sheltered bays including that upstream from Egg Island Point and Spring Bay where *Spartina* had been noted in 1969/70. Separate clumps flanked these marshes, and together with isolated shoots formed an intermittent fringe as far downstream as Batman Bridge. Below this the clumps and shoots were found only in sheltered bays as far as Ruffins Bay on the west shore and East Arm on the east shore.

Viewing the distribution of *Spartina* in the summer of 1971/72 generally, two points are striking. Firstly, whereas *Spartina* had spread only 4 miles (6.44 km) upstream from its place of introduction at Windermere it extended downstream for 14

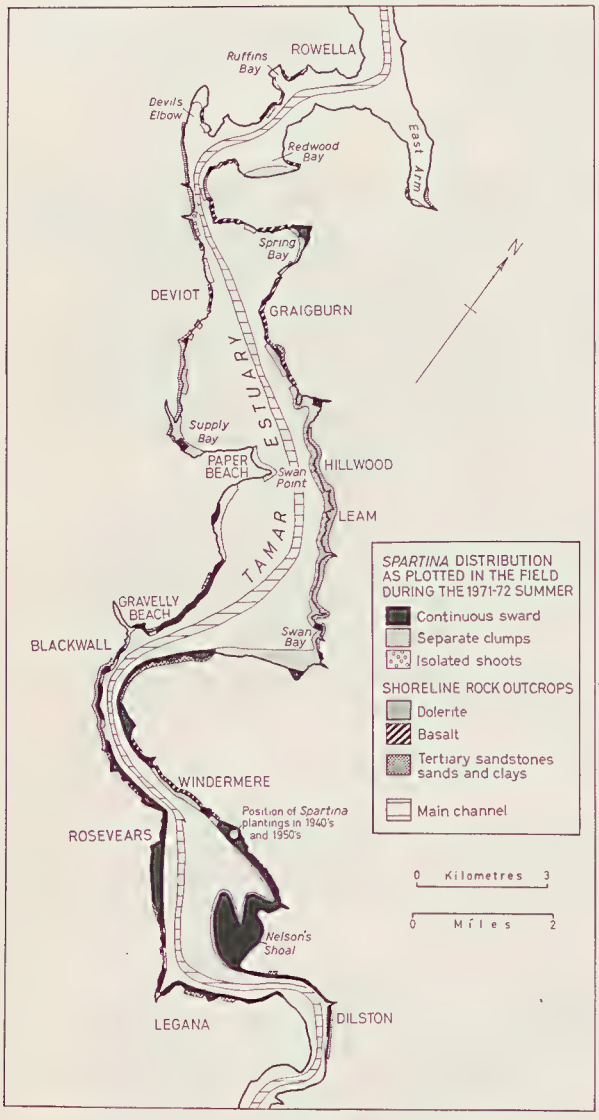


FIG. 3. - *Spartina* distribution and shoreline rock outcrops.

miles (22.54 km). This may be partly explained by the longer period of flow of the ebb tide than the flood, 7 hours as opposed to 6 hours, which will tend to produce a net transport of water, capable of carrying *Spartina* seeds and fragments, downstream. It will also be influenced, mainly indirectly, by salinity and table 2 gives details of measurements taken along the Tamar between September and December 1971.

The uppermost limit of *Spartina* in the Tamar, at Dilston, lay midway between Green Hillock Point and Lone Pine Point, where salinity is very low. Upstream from Dilston extensive areas of *Phragmites* flank both banks of the estuary in that part of the inter-tidal zone which downstream is colonized by *Spartina*. The *Phragmites* growing where low salinity gives way to fresh-water conditions appears to act as a barrier to the spread of *Spartina* upstream. Plantings of *Spartina* were made at an unknown date on the upstream side of Tamar Island, near Green Hillock Point, but these died. A limited, isolated area of plantings, also of unknown date were surviving in a stunted form during the 1971/72 summer at Kelso, near to the Bass Strait entrance to the Tamar. The higher energy conditions in this area are likely to mitigate against the extensive establishment and spread of *Spartina* there. However it seems probable that it will spread further downstream from the main area of colonisation in the central Tamar.

The second noteworthy point relating to the overall distribution pattern is an anomalous section at Windermere adjacent to the area where the original plantings were made, which in 1971/72 was still only colonized by isolated clumps of *Spartina*. Basalt outcrops along this shore as it also does at Hillwood and Deviot where there are gaps in the areas of more recent and sparser colonization.

RATE OF SPREAD OF *SPARTINA*

From the aerial photographs covering most of the central section of the Tamar

during one summer and from the field mapping in the 1971/72 summer the increasing extent of *Spartina* has been measured and details are given in table 3. The spread is plotted in graph form in figure 4.

TABLE 2

CHLORIDE IN G/LITRE

Location	Date			
	15.9.71	2.11.71	12.11.71	15.12.71
Haystack Point	0.0	0.0	0.0	0.0
Green Hillock Point	0.1	0.0	0.0	0.1
Lone Pine Point	3.6	3.8	1.4	4.2
Swan Point	5.4	7.1	3.2	7.3
Batman Bridge	9.7	9.3	9.1	11.4
Big Bay Point	12.1	12.9	12.7	14.3
Beauty Point	15.8	14.2	14.1	15.2
Anchor Point	15.4	15.6	13.9	15.1
Windmill Point	15.9	17.7	19.0	18.4
Shear Rock (Tamar Entrance)	19.0	19.3	19.3	19.3

(By courtesy of the Port of Launceston Authority)

GEOLOGY, SLOPE AND *SPARTINA* COLONIZATION

The section of the Tamar into which *Spartina* has spread is characterised geologically by parallel faulting and marked lithological variations within short distances. The basement rock is Jurassic dolerite, faulted in the late Mesozoic or early Tertiary to produce the Tamar Trough in which silts, sands, clays and gravels were deposited during the Tertiary. Fossil soils, bauxite and ferricrete developed at various levels within the sediments and vulcanism occurred at intervals producing basalt flows.

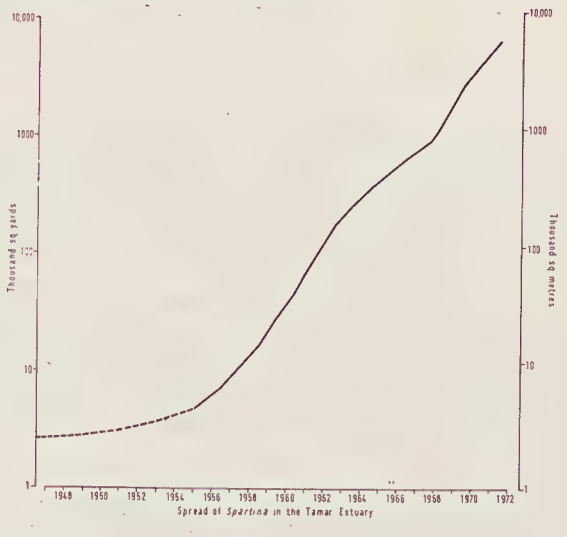


FIG. 4. - Rate of spread of *Spartina*.

Figure 3 shows the outcrops of the different rock groups along the shore where *Spartina* was present during the 1971/72 summer. The dolerite and basalt outcrops produce steep, irregular shores, with small promontories and embayments and angular boulders up to several feet in diameter. On the upstream outcrops of dolerite at Dilston, Lanena and Blackwall, where *Spartina* was present in March 1969, there was a continuous sward or isolated clumps by the 1971/72 summer. Along the dolerite shores downstream between Swan Bay and Egg Island and between Supply Bay and Whirlpool Reach, where no *Spartina* was visible on any of the aerial surveys, clumps and isolated shoots were extensively established by 1971/72. They were denser in sheltered embayments

and hollows where small amounts of mud had accumulated on top of the dolerite, but shoots were establishing in the lee of large boulders where only a thin veneer of mud was present. The sparsity of *Spartina* colonization along the basalt shores contrasts with that along the dolerite shores. Attention has already been drawn to the section at Windermere, adjacent to the area of initial introduction where only isolated clumps were present in 1971/72 and to the downstream outcrops at Hillwood and Deviot where there are gaps in the more recent and generally sparser colonization.

TABLE 3

SPREAD OF *SPARTINA*

Date	Area 1,000 sq. yds.	1,000 sq. metres	
March 1961	60	50.17	continuous sward and separate clumps
January 1963	180	150.50	" "
March 1968	c. 950*	794.30*	" "
Summer 1969/70	2,840	2,374.52	" "
Summer 1971/72	4,090	3,419.65	continuous sward
Summer 1971/72	2,380	1,989.92	separate clumps
Summer 1971/72	170	142.14	isolated shoots
Summer 1971/72	6,640	5,551.70	total

*Rosevears - Blackwall not included in survey, small allowance made in area calculation.

The Tertiary sandstones, sands and clays produce a smoother, more regular shore of lower gradient. Along the earlier colonized, upstream outcrops, *Spartina* by 1971/72, formed a continuous marsh and in the downstream more recently colonized areas over half these outcrops had isolated clumps and shoots growing on them. In places the *Spartina* roots were penetrating into the weathered rocks, especially the clays, and elsewhere the *Spartina* was rooted in overlying sediments.

Ferricrete outcrops along many parts of the shores of the Tamar in association with any of the other rock types. It characteristically forms extensive "pavements", which may be bare or only thinly veneered with fine sediments. *Spartina* is able to establish in small pockets of sediment and as it traps more sediment so it spreads over the "pavement". *Spartina*, in 1971/72, was found on ferricrete as a continuous sward, separate clumps or isolated shoots, the length of time since initial colonization apparently determining the form.

The most extensive accumulations of fine sediment overlying the rock outcrops are found upstream from Windermere and including Nelson Shoal, at Rosevears and between Gravelly Beach and Swan Point where they produce intertidal areas of very low gradient. In the first of these areas a very rapid rate of colonization has occurred since 1968 to give the largest continuous *Spartina* sward in the estuary.

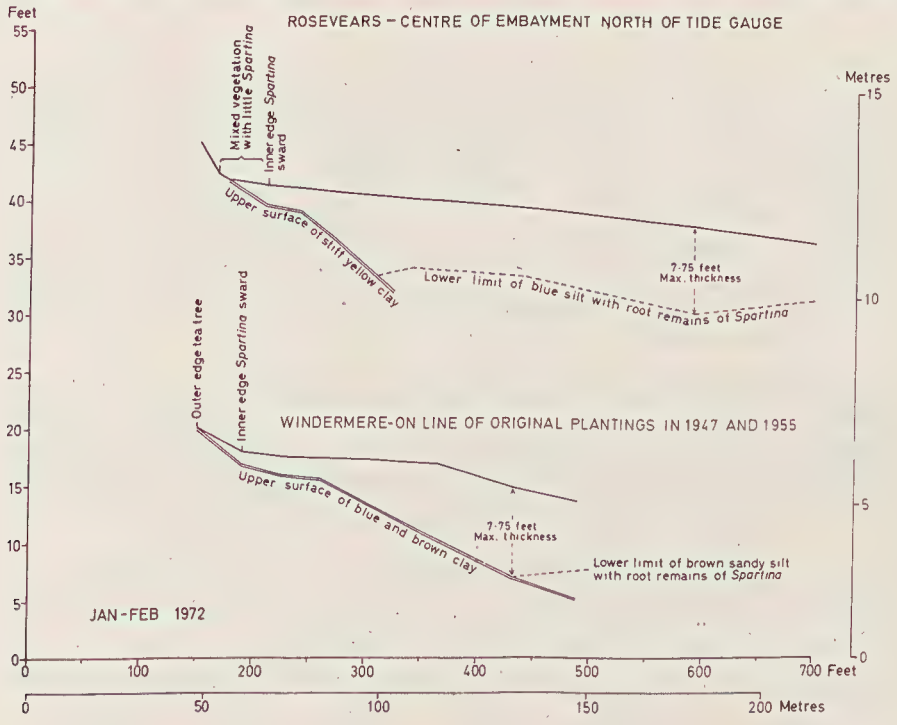
Measurements of the slope of the intertidal zone where *Spartina* is growing show that it is capable of colonizing slopes of up to 28° at least, and there are therefore probably none around the Tamar estuary unsuitable for it. Clumps and shoots were found on slopes ranging from 1° to 28° with an average of 5.6°. As *Spartina* begins to trap silt, so the slope begins to decrease. Slope measurements in the continuous *Spartina* swards show them to range between 1° and 14° with an average of 2.2°. The steeper slopes are found in the narrow belts of continuous sward, colonizing dolerite

outcrops as at Dilston, or found where the main channel lies close to the bank as around Crescent Shore and at Dilston. The lowest angle slopes are found in the broad mature swards as on Nelson Shoal and in many embayments.

RELATIONSHIP BETWEEN *SPARTINA* AND TIDAL INUNDATION

In the longest established *Spartina* marshes, it has extended down to approximately 4 feet (1.20 m) and up to approximately 10 feet (3.05 m) above George Town Chart Datum. The semi-diurnal components within the diurnal tidal regime produce the following sequence of tides: low low, low high, high low, high high, with successive high tides having only about half the vertical difference experienced by successive low tides. Only during the minimum neap tides does the high high tide fail to cover the uppermost part of the *Spartina* marsh diurnally, and during spring tides the high high and low high tides will submerge the whole marsh semi-diurnally. The lowest area of the *Spartina* is exposed semi-diurnally except during the minimum neap tides when the high low tide is above the lower limits of the grass.

Initial *Spartina* colonization takes place generally in the upper part of the intertidal zone, the shoots and clumps coalesce to give a continuous sward there first and its lower edge with a fringe of clumps and shoots then advances towards low water mark.


ROSEVEARS – CENTRE OF EMBAYMENT NORTH OF TIDE GAUGE
Feet
Metres
Mixed vegetation with little Spartina
Inner edge Spartina sward
Upper surface of stiff yellow clay
7·75 feet Max. thickness
Lower limit of blue silt with root remains of Spartina
Outer edge tea tree
Inner edge Spartina sward
WINDERMERE-ON LINE OF ORIGINAL PLANTINGS IN 1947 AND 1955
Upper surface of blue and brown clay
7·75 feet Max. thickness
Lower limit of brown sandy silt with root remains of Spartina
JAN-FEB 1972
0 100 200 300 400 500 600 700 Feet
0 50 100 150 200 Metres

SECTION THROUGH THE *SPARTINA* SWARDS AT ROSEVEARS AND WINDERMERE

FIGURE 5.

SEDIMENTATION IN THE OLDEST *SPARTINA* MARSHES AT WINDERMERE AND ROSEVEARS

In order to investigate the sedimentation associated with the introduction of *Spartina* into the Tamar Estuary a series of bores were put down along transects at

right angles to the shore at Windermere and Rosevears. The transect at Windermere passed through the position of the acre (4,047 m^2) of plantings carried out in 1955, and that at Rosevears through the area where *Spartina* has been present since 1961 as shown on the aerial photographs. Figure 5 shows the results obtained from these bores.

At Windermere the top of the blue and brown clay which earlier must have formed the surface was easily located. Above this a brown sandy silt had accumulated in the continuous *Spartina* sward and root remains were found down to a maximum depth of 7.75 feet (2.35 m) at a distance of 243 feet (74.73 m) from the inner edge of the *Spartina*. Channelwards a greater depth of sedimentation was recorded above the clay surface but root remains of *Spartina* were found at increasingly shallow depths until at the outer margin of the sward they were found only to a depth of 6 feet (1.83 m).

At Rosevears the earlier surface was cut in a stiff yellow clay. Because this surface sloped relatively steeply, it was traced in the bores only to a distance of 100 feet (30.5 m) from the inner edge of the *Spartina* sward, where it was 7 feet (2.13 m) below the present marsh surface. The blue silt which had accumulated above this and continued channelwards contained root remains of *Spartina* down to a maximum depth of 5 feet (1.53 m) at Rosevears.

CONCLUSIONS

Despite the very slow growth of the early plantings of *Spartina* during the 1940's and mid 1950's, subsequently the introduction has proved highly successful. *Spartina anglica* is clearly well suited to ecological conditions in the Tamar, as is shown by its rapid increase in area by spreading from established colonies, seeding and growth of broken fragments. It is capable of colonizing the fine sediments and outcrops of dolerite, basalt, sandstones, sands, clays and ferricrete which at present form the shores and intertidal zone of the Tamar. The fine sediments however appear to provide the most favourable substrate and the basalts the least suitable. None of the range of slopes from 1° to 28° measured in the intertidal zone precludes colonization. The tidal regime provides a vertical range of about 6 feet (1.83 m) towards the upper part of the intertidal zone where frequency and duration of inundation and emergence are suitable for *Spartina* growth.

The initial aim in introducing *Spartina*, the stabilization of the mud banks and the safeguarding of the navigable channel in the Windermere and Rosevears area has undoubtedly been achieved. A similar effect has resulted in many other parts of the estuary. Not only have the banks been stabilized by the colonization of *Spartina* they have also been raised markedly in height as has been demonstrated at Windermere and Rosevears. They are therefore subject to less frequent and shorter periods of tidal inundation, and the tidal streams are more confined in the main channel.

However, the rapid spread of *Spartina*, generally indiscriminate of substrate and degree of slope within much of the intertidal zone has caused problems. A number of sand beaches with recreational facilities or potential have been at least partly invaded by *Spartina* and many private jetties have become useless as it has spread around them. Despite experimentation with a range of herbicides, which have proved a successful means of controlling *Spartina* in other parts of the world none had been successful up to 1972 in the particular range of ecological conditions found in the Tamar.

ACKNOWLEDGEMENTS

The project was undertaken whilst the author was on sabbatical leave in the Geography Department at the University of Tasmania and she is grateful for the facilities which were made available. Special thanks are due to Professor J.L. Davies now of

Macquarie University, Sydney, for his advice and encouragement over the project and for his constructive comments on the manuscript. The Port of Launceston Authority, the Department of Agriculture and the Queen Victoria Museum in Launceston, together with the Department of Lands and Surveys and C.S.I.R.O. in Hobart provided much valuable information including access to an unpublished report by T.E. Emmett, "Report on the Tamar Estuary for the Marine Board of Launceston", 1963, now held by the Port of Launceston Authority.

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A NEW SPECIES OF *SAGITTA* (CHAETOGNATHA) FROM D'ENTRECASTEAUX CHANNEL, TASMANIA

by Nyan Taw

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(with one table and two text figures)

ABSTRACT

A new species of the genus *Sagitta* (Chaetognatha), *S. guileri* sp. nov. found in D'Entrecasteaux Channel, Tasmania is described and figured. Its relation to *S. neglecta* Aida is discussed and its distribution in the south-east coastal waters of Tasmania is given.

INTRODUCTION

During a study of the zooplankton of the south-eastern coastal waters of Tasmania, an abundance of specimens of a species of *Sagitta* were collected in the northern parts of D'Entrecasteaux Channel, southern Tasmania. These specimens differ from all known species and are considered to represent a new species for which the name *Sagitta guileri* sp. nov. is proposed. The species is named in honour of Dr. E.R. Guiler, Reader in Zoology, University of Tasmania.

DESCRIPTION OF SPECIES

Sagitta guileri sp. nov.

(figs. 1a-g)

Type Material

Holotype, paratypes 10; Tasmanian Museum Registration Nos. K762 - K763. Taken in a midwater (10 m) plankton tow during the night of 22nd December 1971, off Barnes Bay, Bruny Island, D'Entrecasteaux Channel, Tasmania.

Description

Body length, 8.0 - 10.5 mm based on 25 mature (stage IV) specimens.

Body rigid and opaque in formalin preserved specimens; length of fully mature (stage IV) specimens reaches to 10.5 mm; head is of normal size, approximately equal to the widest region (mid region) of the body; hooks totally concealed if viewed from dorsal side of head; eyes rounded with the pigmented area well developed and in the form of letter 'T' lying sideways with the top part pointing laterally; intestinal diverticulum present but not obvious; corona ciliata absent.

Tail region forms between 25.5 and 29.6% of the total body length (excluding the tail fin); the number of hooks may be 6 or 7; the number of anterior teeth is either 4 or 5; there are between 6 to 9 posterior teeth.

Collarette present, extending from head to tail region as far as middle region of the tail fin; relatively thicker at the neck and the vicinity of seminal vesicles.

Anterior fin begins at a distance (approximately 4.0% of the body length) behind posterior end of ventral ganglion; elliptical in shape; shorter than posterior fin with the widest part at the middle region; entirely supported by rays.

Posterior fin long and situated more on tail region than on the body; completely

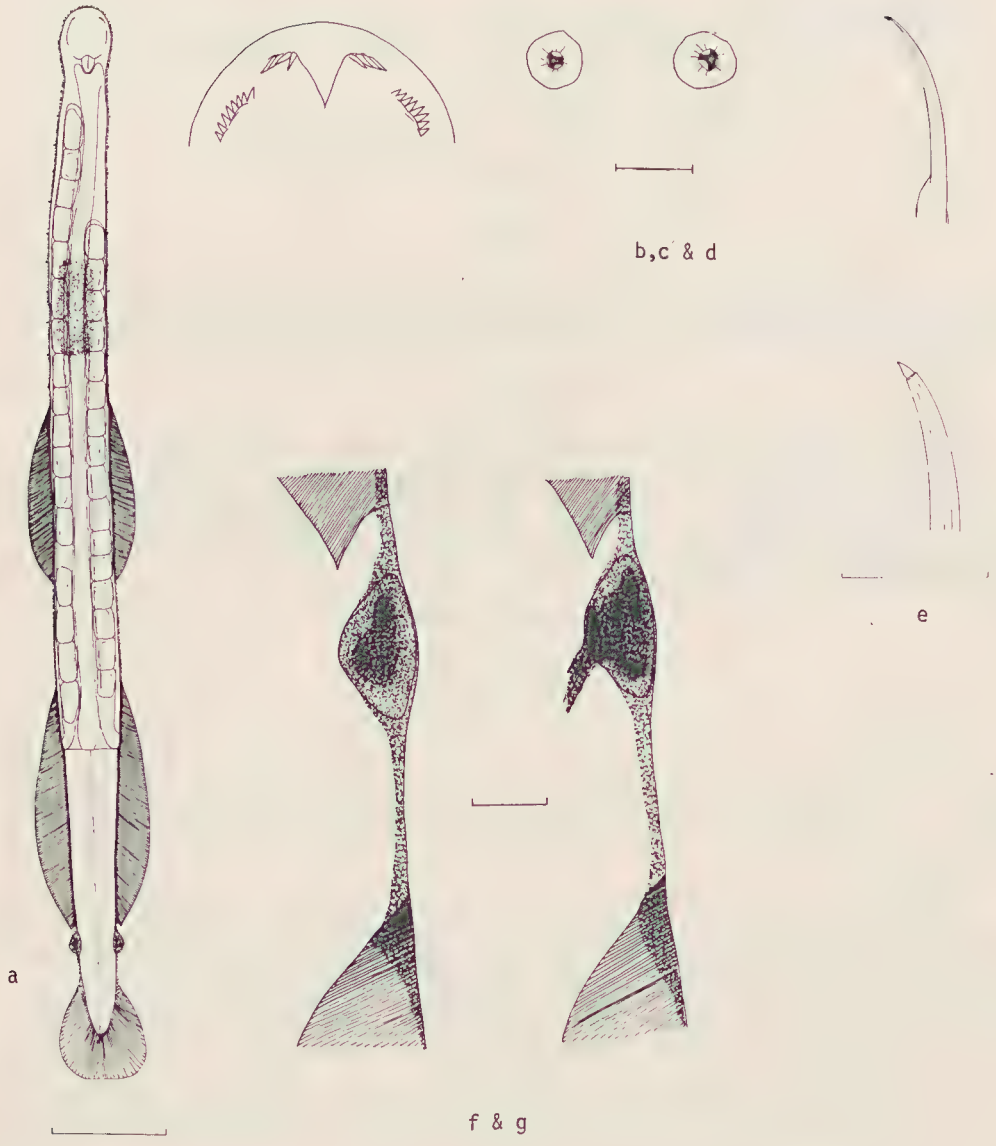

FIG. 1. - *Sagitta guileri* sp. nov.
a. Entire animal, ventral view (scale 1.0mm long).
b. Ventral view of anterior region of the head showing anterior and posterior teeth (scale 0.1mm long).
c. Detailed structure of eyes (scale as b.).
d. Detailed structure of 3rd right hook (counted from ventral side) (scale as b.).
e. Detailed structure of distal region of 3rd right hook (scale 0.05mm long).
f. Mature seminal vesicle (scale 0.1mm long).
g. Mature seminal vesicle (bursting) (scale as f.).

supported by rays; posterior end terminates just in front of anterior tip of seminal vesicles.

Ovaries long, one on each side reaching up into the neck region; ova rounded and large, in one row, filling the body cavity.

Seminal vesicles situated near posterior fin; roundish to triangular in shape with the protuberance at the mid-lateral region; bursting at the protuberance (mid-lateral edge) when mature.

DISTRIBUTION

S. guileri sp. nov. was very abundant in the northern parts of the D'Entrecasteaux Channel. The maximum number collected in a tow was 1005 (72.9 specimens per cubic meter). It was captured usually during night tows and found to be abundant from November to January. During the remaining months the number observed was low (less than 1.2/cubic meter).

A large number of inshore and offshore coastal zooplankton samples have been studied. However, *S. guileri* sp. nov. was found only in the inshore waters. The localities of zooplankton stations sampled and those where *S. guileri* sp. nov. was encountered are shown in fig. 2.

DISCUSSION

Sagitta guileri sp. nov. belongs to the 'neglecta' group (Tokioka and Pathansali 1963; Alvarino 1967) being most closely related to *S. neglecta* Aida. The main characters in which it can be distinguished from *S. neglecta* are: i) low number of posterior teeth; ii) position of anterior fin in relation to ventral ganglion; iii) extended length of ovaries; iv) shape of seminal vesicles. In table 1, characteristic features of *S. guileri* sp. nov. are compared with those of *S. neglecta* Aida described by Michael (1911, 1919), Thomson (1947), Sund (1959), Tokioka (1959), and Alvarino (1967).

The absence of the corona ciliata in *S. guileri* sp. nov. is one of the main features in which it differs from *S. neglecta*. However, this character is of small taxonomic value owing to the fact that the corona ciliata does not usually persist in 5% formalin preserved specimens (Alvarino 1967).

The number of posterior teeth in *S. guileri* sp. nov. is low compared with *S. neglecta* (table 1). Californian specimens of *S. neglecta*, apart from having a low number of posterior teeth, have the remaining characters agreeing with *S. neglecta* (Michael 1911). Ritter-Zahony (1911) recorded the number of posterior teeth in his *S. neglecta* specimens from tropical waters of Indian and Pacific Ocean, as 12 to 18 in large specimens (7 - 10 mm).

Michael (1919) found in his Philippine specimens that three out of ten specimens he studied had the anterior fin beginning 1.0 to 1.5% of the body length behind the ventral ganglion. In the remaining specimens the anterior fin began at the ventral ganglion. Similarly, Alvarino (1967) described her specimens of *S. neglecta* from South China Sea and the Gulf of Thailand as having the anterior fin beginning a short distance behind the posterior end of the ventral ganglion. From her figures (Alvarino 1967, p. 179, figs. 46A-D) it is evident that the anterior fin begins approximately 1.0% of the body length, behind the ventral ganglion. Ritter-Zahony (1911) reported that his *S. neglecta* specimens had the anterior fin beginning just behind or a little way behind the ventral ganglion. In *S. guileri* sp. nov. the anterior fin begins approximately 4.0% of the body length behind the ventral ganglion.

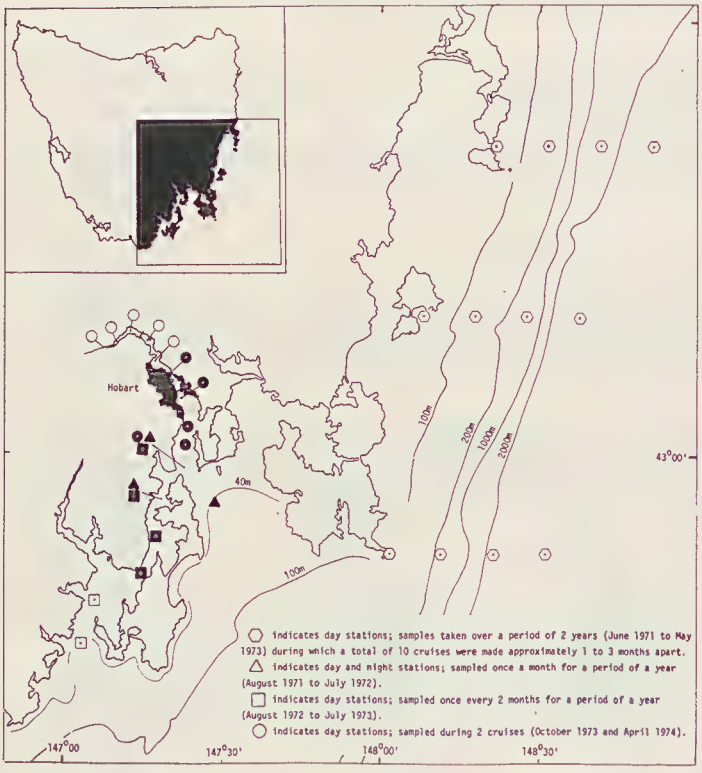
Hobart
40m
100m
100m
200m
1000m
2000m
43°00'
147°00
147°30'
148°00'
148°30'
indicates day stations; samples taken over a period of 2 years (June 1971 to May 1973) during which a total of 10 cruises were made approximately 1 to 3 months apart.
indicates day and night stations; sampled once a month for a period of a year (August 1971 to July 1972).
indicates day stations; sampled once every 2 months for a period of a year (August 1972 to July 1973).
indicates day stations; sampled during 2 cruises (October 1973 and April 1974).

FIG. 2. - Zooplankton stations in the south-eastern coastal waters of Tasmania.
Solid symbols indicate stations where *S. guileri* sp. nov. was found; open symbols indicate stations where *S. guileri* sp. nov. was not found.

The structure of ovaries and ova of *S. guileri* sp. nov. is similar to that of *S. neglecta* described by Alvarino (1967). However, in *S. neglecta* the ovaries reach up to midway between the neck and ventral ganglion whereas in *S. guileri* sp. nov. they extend into the neck region.

The seminal vesicles of *S. guileri* sp. nov. differ from those of *S. neglecta* in shape (see table 1). The shape of the seminal vesicles of *S. neglecta* has been described by Alvarino and as claimed by Michael (1911) is similar to that of the seminal vesicles of *S. serrato-dentata*.

The relationship of *S. guileri* sp. nov. to material from south eastern Australia recorded (Thomson 1947) as *S. neglecta* is not clear (table 1). However, Professor Thomson, after examining material of the new species has expressed the opinion (personal communication) that "a careful comparison of *S. guileri* sp. nov. and recognised *S. neglecta* from Port Hacking may well suggest consistent differences." Unfortunately, an attempt to obtain samples of this material for comparison with that described herein was unsuccessful.

ACKNOWLEDGEMENTS

Sincere thanks are due to the following: Dr. E.R. Güiler and Dr. J.L. Hickman for their encouragement and critically examining the manuscript; the skipper of the Zoology Department Research Vessel 'Neotrigonia', Mr. T. Sward, for his help in the field; Professor J.M. Thomson, Head of Zoology Department, University of Queensland, for examining the specimens and helpful comments; Mr. F.B. Griffith, Curator of Zooplankton, Division of Fisheries and Oceanography, C.S.I.R.O., Cronulla, for examining the specimens.

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TABLE 1

COMPARISON OF *S. GUILERI* SP. NOV. WITH *S. NEGLECTA* AIDA

	S. guileri sp. nov.	Alvarino (1967)	Thomson (1947)
Length (mm)	8 - 10.5	8.0	8 - 10
Body	Opaque and strongly built	Firm, rigid, opaque with strong muscles.	-
Head	Normal size, about or less than the widest part of the body.	Regular or small.	-
Eyes	Rounded, pigmented area strong, dark and in the form of a 'T' lying sideways with top part pointing laterally.	Roundish; pigmented area shaped like a five pointed star with three large arms and two small.	-
Intestinal diverti-culum	Present.	Appear at the anterior end of the digestive tract.	-
Corona ciliata	Absent (5% Formalin preserved specimens).	Clearly visible, and it extends in a weaving pattern from a location between the eyes to midway from neck to ventral ganglion.	-
Tail %	25.5 - 29.6	26 - 30	27 - 32
Hooks	6 - 7	6 - 7	6 - 8
Anterior teeth	4 - 5	7	5 - 7
Posterior teeth	6 - 9	up to 18	9 - 16
Collarette	Present, extending from head to tail as far as middle region of tail fin. Relatively thicker at the neck and vicinity of seminal vesicle.	Filling neck region to anterior fins and as a thin layer to tip of tail.	-
Anterior fin	Beginning at a distance (approximately 4.0% of the body length) behind ventral ganglion. Shorter than posterior fin and completely rayed.	Beginning a short distance behind posterior end of ventral ganglion; shorter than posterior fin; no rayless zone present.	-
Posterior fin	Long and elliptical in shape; more on the tail region. Posterior end terminates just in front of anterior tip of seminal vesicles. Completely rayed.	Beginning at a short distance behind anterior fins; extending to seminal vesicles; elliptical in shape; located more on tail (2/3 of their length) than trunk; no rayless zone.	-
Ovaries	Long, reaching up into the neck region (one on each side). Ova rounded and large in one row; filling the body cavity.	Wide tubes filling trunk cavity and reaching up to midway between neck and ventral ganglion; ova round, large and arranged in one row.	-
Seminal vesicles	Roundish to triangular in shape protuberance at the mid-lateral edge; bursts at the mid-lateral edge when mature. Nearer to posterior fin.	Touching end of posterior fins, apart from tail fin; distance of seminal vesicles to tail fin is about equal length of vesicles; roundish with anterior part more voluminous, with a protuberance at anterior end at the base of which a fission line is visible; bursting along that line extending towards lateral edge of dorsal side to posterior end of vesicles.	-

S. neglecta Aida

Tokioka (1959)	Sund (1959)	Michael (1919)	Michael (1911)
6.8 - 8.1	7.3	6.5 - 8	7.9 - 12
-	Firm, semi-opaque.	-	Firm, rigid, retaining its form well.
-	-	-	-
-	-	-	-
-	Present.	-	-
-	-	-	-
28 - 32.4	27 - 31(27.4)	30 - 33.5	26 - 30
6 - 8	6 - 8(7)	6 - 7	7 - 9
5 - 8	5 - 7(5)	4 - 8	3 - 5
13 - 18	13 - 17(17)	12 - 16	8 - 11
-	Present.	-	Extends from neck region to well forward, but never reaches the ventral ganglion.
-	Starts at ventral ganglion.	Three specimens out of 10 specimens studied had the anterior fin beginning 1.0 to 1.5% of the body length behind ventral ganglion. Remaining specimens begin at ventral ganglion.	Shorter and narrower than posterior fin. Extends to posterior end of ventral ganglion. In form it is narrowly and acutely triangular.
-	Reaches seminal vesicles.	Posterior end touching seminal vesicle.	Extends nearly, if not quite to seminal vesicle when seminal vesicles are timid. Half elliptical in form.
-	Containing round ova, extending anterior to posterior border of anterior fin.	-	-
-	Rounded.	-	The seminal vesicles do not present such decided contrast as in *S. serratodentata*.

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CAMBRIAN STRATIGRAPHY OF THE ST. VALENTINES PEAK AREA, NORTH-WESTERN TASMANIA

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(with three text-figures)

ABSTRACT

An important Late Middle Cambrian fossil locality occurs 2 km west of St. Valentines Peak in north-western Tasmania. The Cambrian rocks to the north and west of St. Valentines Peak are exposed in the core of the north-south trending St. Valentines Peak Anticline. In the best exposed section (3 km north of the main fossil locality), the oldest Cambrian unit is a massive, cherty, pyritic meta-sandstone and meta-siltstone at least 100 m thick. This is overlain by 100 m of rhyolitic welded tuff, 75 to 100 m of meta-sandstones and meta-siltstones, 100 m of a possible contact metasomatic rock and 230 to 375 m of a pale grey chert which in turn is overlain by about 17 m of fine breccia and poorly fossiliferous siltstone. This sequence is overlain with probable disconformity by the basal chert conglomerate of the essentially Ordovician Junee Group. It is suggested that the sediments of the main fossiliferous locality occur stratigraphically below the section noted above. The Cambrian and Ordovician rocks are intruded by Devonian granite and partly overlain by Tertiary basalt.

INTRODUCTION

The purpose of this paper is to give a brief outline of the Cambrian geology of the St. Valentines Peak area. This area is important because in 1963 G. Pike discovered some of the best preserved Cambrian fossils in Tasmania in a deeply weathered siltstone near the corner of Hampshire Park Road and Gin Creek Road (lat. 41°21.6'S, long. 145°44.3'E). The fossils were discovered subsequent to the reviews of the Tasmanian Cambrian System by Banks (1956, 1962). During the last ten years the writers have independently mapped the area for various purposes. Pike did the initial work and produced the first regional geological map of the St. Valentines Peak area; Mills considered the area in relation to the mineralization around the Hampshire Hills Granite; Jago mapped the area for biostratigraphic purposes.

The Cambrian rocks of the St. Valentines Peak area are poorly exposed with a thick vegetation cover in some places. Road cuttings and quarries are the principal sources of geological information.

CAMBRIAN STRATIGRAPHY

The Cambrian rocks to the north and west of St. Valentines Peak are exposed in the core of the essentially north-south trending St. Valentines Anticline (fig. 1). They are overlain with apparent conformity, but with probable disconformity, by a chert conglomerate which is the basal member of the Junee Group in this area. These sediments were later intruded by Devonian granite and finally partly covered by Tert-

iary basalt.

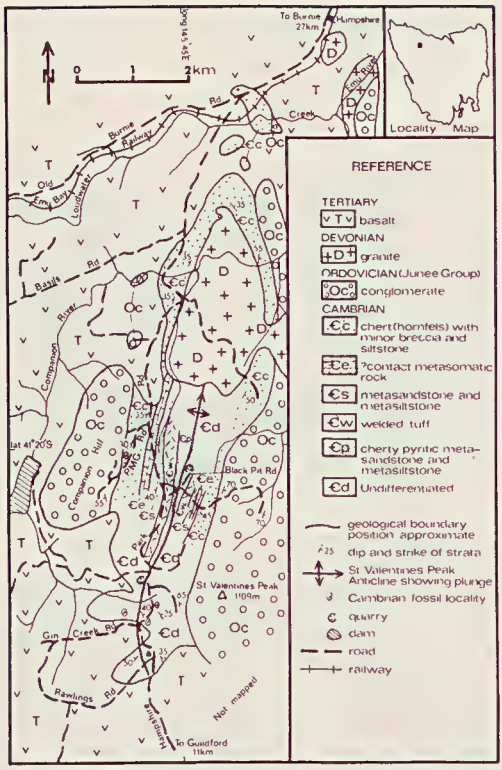

FIG. 1. - Geology of the St. Valentines Peak Area.

The best exposed sections are along the PMG Road, Black Pit Road and adjacent roads, and along Hampshire Park Road between PMG Road and Black Pit Road, (fig. 1). North of this area the Cambrian rocks are largely covered by basalt or intruded by granite; south of this area there is considerably less outcrop even in road cuttings. The stratigraphic column for the western limb of the anticline in the PMG Road-Black Pit Road area is described below and summarized in figure 2. No formal stratigraphic nomenclature is set up due to the rather poor outcrop and the small size of the mapped area.

The lowest unit exposed in the PMG Road-Black Pit Road area is a massive cherty, pyritic meta-sandstone and meta-siltstone (at least 100 m thick) which is well exposed in the quarry at the end of Black Pit Road. The overlying unit is a devitrified incipiently to moderately welded tuff of rhyolitic to rhyodacite composition. Devitrified cuspate shards are common in the ground mass; there are some small recrystallized spherulites; the quartz phenocrysts are angular to rounded. The whole assemblage is typical of an ash flow. This unit is about 100 m thick.

The welded tuff is overlain by about 75 to 100 m of poorly exposed meta-sandstones and meta-siltstones. The overlying unit is about 100 m thick. In outcrop it has a green and white striped appearance with the white stripes being more resistant to weathering. This unit is concordant with the surrounding units. In thin section the green parts of the rock are distinctly nodular and consist of epidote group minerals, diopside (?), minor amounts of scapolite, tremolite (reasonably common) and isolated nodules of vesuvianite. The white parts of the rock are much finer-grained and consist largely of a mineral, with low bi-refringence, which cannot be identified with certainty. Traces of carbonate and some clay are also present in the finer

grained parts of the rock. The composition of the rock varies considerably over a short distance, but its overall appearance remains the same. This rock is possibly of contact metasomatic origin and may have been an impure limestone or dolomite which was affected by the intrusion of the Devonian granite.

The overlying unit is a hard laminated and non-laminated, slightly pyritic, pale grey chert (hornfels), which is about 375 m thick on the western limb of the anticline and about 230 m thick on the eastern limb of the anticline. The chert weathers to a buff-coloured siltstone. It is overlain by 1.5 m of deeply weathered brown siltstone and 11 m of grey siltstone. Overlying the grey siltstone is a 50 cm lens of microbreccia which is separated by about 1 m of grey siltstone from a lens of breccia which varies from 15 to 45 cm in thickness over the 2 m in which it is exposed. This upper breccia lens consists of angular pebbles of chert and quartzite up to 2 cm across, but which average 0.5 to 1 cm across. It tends to be disconformable on the underlying siltstone.

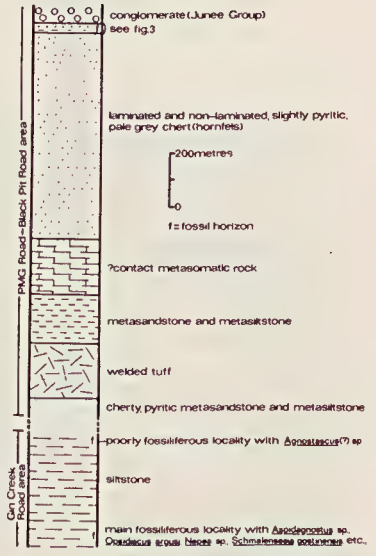
conglomerate (Junee Group)
see fig.3
laminated and non-laminated, slightly pyritic, pale grey chert (hornfels)
200metres
0
f = fossil horizon
?contact metasomatic rock
metasandstone and metasiltstone
welded tuff
cherty pyritic metasandstone and metasiltstone
poorly fossiliferous locality with Agnostascus(?) sp
siltstone
main fossiliferous locality with Aspidagnostus sp.
Opsidiscus argusi Nepea sp. Schmalenseeia gostinensis etc.
PMG Road - Black Pit Road area
Gin Creek Road area

FIG. 2. - Stratigraphic column of the Cambrian rocks of the St. Valentines Peak area showing the possible stratigraphic relationship between the rocks of the PMG Road - Black Pit Road area and those of the Gin Creek Road area.

The upper breccia lens is overlain by 3.5 m of poorly fossiliferous, micaceous grey-green siltstone and interbedded fine breccia beds. The fossils are unidentifiable brachiopod and trilobite fragments discovered at lat. 41°20.2'S, long. 145°44.1'E. Despite intensive collecting, no recognisable trilobites have been found. The fossiliferous siltstone is separated from the basal Junee Group conglomerate by a 5 to 10 cm band of very fine grey siltstone.

The section across the contact between the Junee Group conglomerate and the sediments described above is shown in figure 3. The contact is very sharp but is slightly uneven suggesting slight disconformity rather than conformity. The nature of the contact on the eastern side of the anticline where faulting makes interpretation difficult, is much less clear.

The main Cambrian fossil locality in St. Valentines Peak area at lat. 41°21.6'S, long. 145°44.3'E is about 3 km south of the section discussed above. Part of this fauna has been described (Jago 1972b; Jago and Daily 1974). Trilobites found at this locality include *Schmalenseeia gostinensis*, *Nepea*, a zacanthoid, *Opsidiscus argusi*, *Peronopsis*, *Clavagnostus* (?) *rawlingi*, *Aspidagnostus*, *Agnostascus* (?) and others. This Late Middle Cambrian fauna is either of the *Lejopyge laevigata* III Zone of Öpik (1961) or Öpik's (1967) *Damesella torosa-Ascionepea janitrix* Zone (Jago 1972b). The

rocks of the southern part of the mapped area are shown in figure 1 as Cambrian Undifferentiated. They include deeply weathered meta-siltstones and meta-sandstones with some acid volcanics.

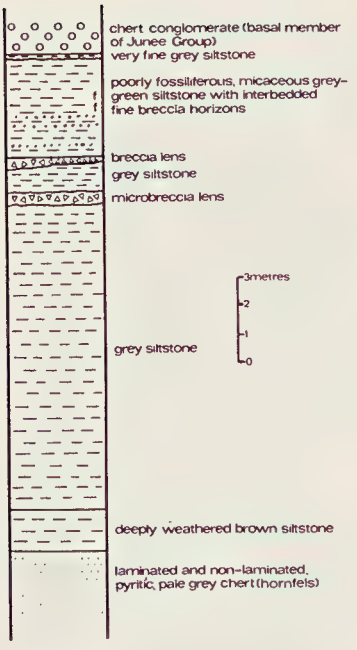

FIG. 3. - Cambrian-Junee Group contact, PMG Road, Companion Hill (lat. 41° 20.2'S, long. 145°44.1'E).

In the area where the fauna noted above is found, the outcrop is very poor. In fact, the best fossils are found in sediments trapped in the roots of fallen trees. There are three other fossil localities in the immediate vicinity (fig. 1). All are found in road cuttings of the Hampshire Park Road. The central of these three localities appears to have a similar fauna to that noted above. The northernmost locality at lat. 41° 21.4'S, long. 145°44.6'E has only very poorly preserved fossils which include unidentified polymerid trilobites and *Agnostascus* (?). Its stratigraphic position indicates that it is slightly younger than the main fauna. The southernmost locality, at the junction of Hampshire Park Road and Rawlings Road is represented by a single poorly preserved agnostid pygidium.

The outcrop in the area where the main Late Middle Cambrian fauna is located is insufficient to determine its exact stratigraphic position with respect to the units of the PMG Road-Black Pit Road section. However, if the structure as shown in figure 1 is correct, then this fauna occurs stratigraphically slightly below the lowest unit of the PMG Road-Black Pit Road section (fig. 2). Concealed faults could alter the situation (as shown in fig. 2) so that the sediments of the main fossil locality correspond to some of the sediments from the PMG Road-Black Pit Road area. For example, they may correspond to either the "meta-sandstone and meta-siltstone" unit above the welded tuff or to the chert unit (which, as shown above, weathers to a siltstone) above the ?contact metasomatic rock. The latter possibility is supported to some extent by the slightly cherty nature of some of the deeply weathered meta-siltstone near the corner of Gin Creek Road and Hampshire Park Road. However, at present fossils such as those found in the southern part of the area are unknown from the PMG Road-Black Pit Road area, and the situation as shown in figure 2 is preferred.

JUNEE GROUP CONGLOMERATE

Descriptions and discussions of the Cambrian rocks of Tasmania have usually stopped at the base of the Junee Group most of which is of Ordovician age (Corbett and Banks 1974). However, it has become apparent that the basal parts of the Junee Group in different parts of Tasmania are probably Late Cambrian (Quilty 1971; Jago 1972a).

Hence, a brief description of the basal Junee Group conglomerate from the St. Valentines Peak area is given below. The best exposures of this conglomerate occur on the PMG Road with additional outcrop occurring beneath a transmission line which runs east-west on the western flank of Companion Hill.

There is about 450 m of conglomerate exposed on Companion Hill. It is generally a poorly-sorted chert conglomerate with pebbles of white and grey chert set in a sandstone matrix. Quartzite pebbles are moderately abundant. There are rare red and green chert pebbles and very rare basic igneous rock fragments. The chert pebbles are generally less than 1 cm across with the larger pebbles tending to be better rounded than the smaller ones. There are some coarser layers with pebbles up to 5 cm across. In such layers the coarser pebbles are usually quartzite. There is a one metre thick micaceous siltstone horizon at the point where PMG Road forks near the top of Companion Hill.

The conglomerate is very poorly bedded with alignment of elongated pebbles outlining the stratification rather than distinct bedding planes. This alignment of pebbles probably indicates a high flow regime at the time of deposition. Rare examples of imbrication indicate a westerly source area.

In the top 30 m of the section exposed beneath the transmission lines to the west of Companion Hill the conglomerate becomes much coarser with the percentage of quartzite fragments increasing markedly. Quartzite is more abundant than chert at some levels in this part of the section. These quartzite boulders are mostly well rounded and up to 20 cm across. The chert fragments in these layers are angular and mostly smaller than the quartzite. Only a few chert pebbles are over two cm across, even where the quartzite boulders are up to 20 cm across, but a few chert boulders are 15 cm across. This change in pebble content probably indicates a change of source area.

ACKNOWLEDGEMENTS

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RECENT WHALE STRANDINGS IN NORTHERN TASMANIA

by E.O.G. Scott and R.H. Green

(with three tables and two plates)

ABSTRACT

Three strandings of whales have recently occurred on the north coast of Tasmania. They involve a single pilot whale, *Globicephala* sp., amd two large schools of the false killer whale, *Pseudorca crassidens*.

INTRODUCTION

A stranding of a pilot whale (*Globicephala* sp.) was reported on 9.5.1973, and upon inspection by one of us (R.H.G.) the animal was found to be stranded head seawards at the high tide mark on rocks at the northern end of Greens Beach, northern Tasmania (plate 1). It was fresh and appeared to have died within the previous few days. The colour was uniform black. The dentition was $\frac{9\ 9}{7\ 7}$. A series of measurements is given in table 1.

PLATE 1. - Pilot whale stranded at Greens Beach, May 1973.

Upon dissection the uterus appeared empty, and the stomach contained only a small quantity of white seaweed-like material. The head was removed for subsequent preparation of the skull, and within the nasal cavity there was found a considerable number of nematodes, later determined as *Stenurus* sp., probably *S. globicephalae* Baylis and Daubney, 1925. Specimens of the dolphin *Lagenorhynchus acutus* Gray, 1828 stranded on the coast of Massachusetts, U.S.A., in May 1973 were studied by members of the staff of the New England Aquarium in an endeavour to determine a possible cause of the stranding. It was discovered the nasal cavity and the inner ear of these animals were infested with *S. globicephalae* (pers. com. Louis Garibaldi).

No barnacles or other ectoparasites were observed in our specimen.

If the view of Van Bree (1971) that within the genus *Globicephala* Lesson, 1828 only two species can be recognised, *G. melaena* (Traill 1809), and *G. macrorhynchus* Gray, 1846, the animal here noted is referable to the latter. However, some authors are inclined to believe that of upwards of a score of other nominal species one or more may be valid, and it is clear that, in spite of some recent useful preparatory work, the taxonomy of the genus at present remains uncertain, particularly in respect of species and/or subspecies occurring in the southern hemisphere.

The second stranding, that of the false killer whale (*Pseudorca crassidens*) (plate 2), reported in the daily newspapers of 12.6.1974, was of 170-172 false killer whales on Black River Beach, north western Tasmania, near Stanley. The animals probably came ashore the previous day. One of us (E.O.G.S.), with others, visited the

TABLE 1

Measurements (cm) of a specimen of *Globicephala cf. macrorhynchus* stranded at Greens Beach and 9 specimens of *Pseudorca crassidens* stranded at Black River Beach, near Stanley. The index numbers and dimensions are after Norris (1962). (In the field small dimensions of *Pseudorca* measured in cm — eye, mm — larger dimensions to nearest inch).

Index No.	Feature	Pilot	False Killer							
		♀	♂	♂	♂	♂	♂	♂	♀	♀	♀
1	Length to fluke notch	344	236	244	302	381	467	480	384	401	404
2	Length to mid-eye	35	23	32	34	40	40	42	36	30	30
4	Length to gape	23	31	29	31	36	32	33	31	33	31
7	Gape to centre of eye	10	50	46	53	70	65	70	70	67	68
9	Length of head to blowhole	35	22	28	39	45	49	49	42	43	43
10	Length to pectoral	-	44	52	57	66	76	74	53	57	58
11	Length to tip of dorsal fin	165	127	133	163	196	239	252	194	192	191
13	Length to midpoint of genital slit	-	140	136	181	218	249	249	239	259	244
22	Max. girth at dorsal origin	-	132	137	165	208	257	239	224	239	220
24	Diameter of eye	2.5	3.0	2.7	2.3	3.2	3.6	3.3	2.7	3.1	3.1
26	Length of genital slit	26	10	7	11	13	13	30	2	2	3
27	Width of blowhole	7	-	40	-	-	-	-	-	45	-
29	Length of pectoral, anterior	52	31	36	43	56	58	70	45	54	56
30	Length of pectoral, posterior	50	29	34	41	54	56	68	43	52	54
31	Width of pectoral	16	11	13	14	19	23	24	17	19	20
31	Height of dorsal fin	26	15	23	23	32	40	38	30	32	31
33	Length of base of dorsal fin	51	41	61	69	89	96	102	66	81	78
34	Width of flukes	87	53	64	66	86	117	116	86	94	97
	Dental complement	$\frac{9}{7}$	just erupting	-	$\frac{11}{10}$	$\frac{7}{9}$	-	$\frac{9}{10}$	$\frac{8}{9}$	-	$\frac{8}{11}$

site on 13-14.6.1974, and, under difficult conditions, collected some data before the animals were buried on the beach.

PLATE 2. - False killer whales stranded at Black River Beach, June 1974. Most of the main mass, looking east. Photo: *The Advocate*.

They were in two groups, the main mass extending over about 100 m, with a smaller compact group of nine lying some 400 m westward. When seen most were half buried in the sand at or near high tide mark, their orientation haphazard.

The colour was wholly and uniformly black, save that in some individuals a sub-elliptical whitish or pearly area embraced the umbilicus, extending several centimetres in advance of it and beyond it. As table 1 shows, the range of the dental complement was 7-11 in both the upper and lower jaw.

Length to caudal notch was recorded for 62 individuals, of which 34 were males, 20 females, sex determination being impracticable in 8 (table 2). Eighteen dimensions were noted for each of 6 males and 3 females (table 1). In October 26 females washed out from the mass grave were measured by one of us (R.H.G.): it is possible this series (table 3) included some animals measured in June.

Tests of the significance of the difference from the male mean of June, October, pooled female means yield t = 2.898, 1.733, 2.939, respectively, the first and third being highly statistically significant (P better than 0.01), the second not being formally significant (P 0.1). The length distributions are tolerably symmetrical, the

number of entries within one standard deviation on either side of the mean (expected values with normal distribution in parentheses) being males 24 (23), June females 15 (14), October females 20 (18) pooled females 34 (31).

TABLE 2

Length to caudal notch (cm) of 62 individuals (34 males, 20 females, 8 unsexed) of *Pseudorca crassidens*, Black River Beach, near Stanley, measured June 1974; arranged in ascending order of magnitude (measurements in field to nearest inch).

Males				Females			Sex?
236	376	432	488	234	379	404	137
267	381	467	488	254	383	409	257
267	391	467	488	279	383	-	325
302	396	467	493	284	384	-	368
302	396	470	498	312	389	-	371
322	396	474	518	335	389	-	396
343	401	479	523	348	396	-	396
395	404	480	-	356	401	-	411
371	411	480	-	373	401	-	-

It was not feasible to undertake any internal examination. A search was made for barnacles and other ectoparasites, but none were seen. One very small individual, 137 cm in length, probably not neonatal, was badly eaten by birds. On the morning of the second day a flock of about a dozen ravens, *Corvus tasmanica* Mathews, 1912, was flushed from the nine separate whales, which now appeared whitish, almost the whole of the skin having been stripped off. After an animal has been on the beach for a day or so, the integument can be peeled off in large pieces resembling sheets of black plastic.

The third stranding was brought to the notice of one of us (E.O.G.S.) on 18.6.1974. It took place on the beach and adjacent flats on the west side of Perkins Island, about 10 km north west of Smithton, approximately 20 km westward from the stranding a week earlier. Mr Jeff Findlay, Health Inspector, Circular Head Municipality, Smithton, reported 43 whales were involved. They appeared to be of the same species as was stranded on Black River Beach,and were thought to have come ashore on the night of 14.6.1974. In view of the isolated character of the site, no attempt was made by the local authority to dispose of the carcases. Perkins Island was the site of a notable stranding in February 1911 (Lillie 1915, Scott 1942a) of a school of 38 individuals (all, or all but one, males) of the sperm whale, *Physeter catodon* Linne, 1758.

The site of the Black River Beach stranding was revisited by one of us (R.H.G.) on 23.10.1974, when it was discovered that about 70 of the whales, buried there the previous June, had been washed from the sand and were scattered for about three miles (5 km) along the beach above high tide. With the assistance of Mr Terence Cashion, Queen Victoria Museum, and Sgt A. Archer, Smithton Police, five heads were taken for skulls and further measurements and other data collected (table 3). Though over four months had elapsed since these whales had died decomposition was only slight, being most pronounced around the mouth. Sexing was a simple matter, males being readily recognisable by the prominently protruding penis. The abdomen of 26 females was opened in an endeavour to assess breeding condition. Four animals were found to be each carrying a single foetus, three being males and one a female. Two foetuses were partly protruding from the genital slit, possibly because of abnormal pressures.

Three were in a head-first position and one was in a breech-birth position. The condition of the uterus in another 14 suggested recent parturition. Eight appeared to have not been pregnant in the present season (table 3). The head of one foetus has been preserved in formalin. Tooth wear in females was not as great as in the largest males, in some of which teeth were reduced to about half length.

TABLE 3

Length to caudal notch, apparent breeding condition, and dentition of 26 female *Pseudorca crassidens* washed from the sand four months after stranding at Black River Beach in June 1974. Individuals may or may not be different from those listed in tables 1 and 2. Some comments on tooth wear are given.

Length (cm)	Breeding condition	Teeth
277	empty	subadult
293	empty	subadult
296	empty	subadult
337	empty	not worn (skull kept)
349	post partum	not worn
360	male foetus (134 cm)	-
361	post partum	-
367	female foetus (122 cm)	not worn (skull kept)
368	empty	-
380	post partum	not worn
380	male foetus (140 cm)	not worn
385	empty	slightly worn
386	empty	-
390	post partum	-
395	post partum	-
396	post partum	-
400	empty	-
405	post partum	-
405	male foetus (163 cm)	slightly worn (skull kept)
406	post partum	-
406	post partum	-
411	post partum	slightly worn
425	post partum	not worn
428	post partum	not worn
452	post partum	not worn
480	post partum	

It is of interest to note that in June 1936 a mass stranding of false killers, involving 90-100 individuals, occurred at Stanley, and the adjacent Walkers Island, only some 38 km westward from Black River Beach: measurements of some specimens made

by one of us (E.O.G.S.) have been recorded by Pearson (1936, 188). Less than a year earlier (October 1935) the same locality had been the site of the coming ashore of a school of about 300 pilot whales (Scott 1942b), regarded by Davies (1960) as representing a southern subspecies *Globiocephala melaena edwardii* Smith, 1834. Several large schools of this species have since died on Tasmanian coasts. Other local occurrences of *Pseudorca crassidens* include one individual at Fanny's Bay, near Piper River heads in October 1957, and some 50 animals at Seal Bay, King Island in September 1958.

Tasmania is, indeed, the type locality of the synonymic *Orca meridionalis* Flower, 1864, described two years after Reinhardt had reported *Pseudorca crassidens* as living in the North Sea, Owen's original material having been found, sixteen years earlier, subfossil in a Lincolnshire fen, the species at that time being presumed to be extinct. This Society's journal for the 1919 session contains a paper (Scott & Lord 1920) on the osteology of a specimen of a false killer stated to have been one of a mixed school (including also *Globicephala melaena* and *Orcinus orca*) that came ashore at Adventure Bay last century.

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NON-MARINE ARTHROPODA OF THE TASMANIAN TRIASSIC

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communicated by M.R. Banks

(with one text-figure and one plate)

ABSTRACT

Conchostracan fossils are described for the first time from Triassic rocks in Tasmania. Taxa present include *Cyzicus (Lioestheria)* spp., *Palaeolimnadia (Palaeolimnadia)* cf. *wianamattensis*, *P. (Palaeolimnadia) banksia* n. sp., *P. (Palaeolimnadia) poatinis* n. sp. other species of *Palaeolimnadia* and *Palaeolimnadopsis tasmanii* n. sp. Two assemblages, one with *Palaeolimnadia* alone, the other with *Palaeolimnadia* and *Cyzicus*. The latter assemblage suggests correlation with the Blina Shale in Western Australia and with the Mangli Beds of India. The conchostracans lived in small, transitory bodies of water (Ed.).

INTRODUCTION

Two groups of conchostracan-bearing samples were available for this study, the University of Tasmania Collection (UT) and the Tasch Collection. The former includes samples from the Ross Sandstone at Poatina, the presumably overlying Knocklofty Sandstone and Shale at Tinderbox Bay (526.65 km E. 5232.5 km N.), Knocklofty (524.7 km E. 5250.225 km N.) and Cascades (524.45 km E. 5250.08 km N.) as well as the still younger bed (according to McKellar 1957 cit. Spry and Banks 1962, p. 226) the Brady Formation at Poatina. The second group comprises the Tasch Collection (TCT) (collected in company with Mr. M.R. Banks) from the Knocklofty Formation of the Knocklofty area, Old Beach (east side of River Derwent, 523.75 km E. 5262.5 km N.) and the beach at Conningham (523.25 km E. 5230.25 km N.) south of Hobart, as well as two quarries in Hobart (fig. 1).

THE FOSSIL BIOTA

Components

The biota represented in the specimens studied is very sparse in non-conchostracan elements. It consists of a single carbonized half of a malacostracan shield (UT 93983) (Pl. 1, fig. 10); carbonized plant debris (slab 54732 on which conchostracan species UT 8 occurs, and slab 54664 on which no conchostracans occur but which contains on several levels, carbonized plant debris); a possible fragment of an insect wing (TCT, Conningham) and on one impression of a conchostracan valve possible epibionts (worm borings) and a probable beaded faecal string (TCT 105, Pl. 1, fig. 9).

Essentially, the conchostracan fossils of the University of Tasmania collection constitute a *Palaeolimnadia* fauna in the Ross Sandstone and a *Palaeolimnadia-Cyzicus* fauna in the possibly younger Knocklofty Formation. The conchostracans of the Tasch Collection from the Knocklofty are characterized by dominance of *Palaeolimnadia* at all localities, but some cyziciids are also present. Since the University and Tasch Collections from the Knocklofty came from different localities (fig. 1) it is apparent that the same faunal elements (with rare exception) spread throughout the area during Knocklofty time.

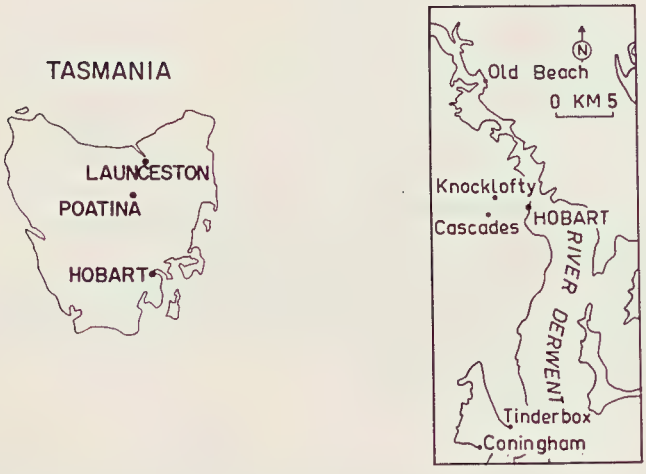

FIG. 1. - Conchostracan Collection Sites.

Preservation

In all instances fossil preservation is extremely poor. Many specimens are known only as external valve impressions. Coquinoid assemblages lead to obscuring of many valves by overlapping ones. Erosion has removed a good deal of data from numerous remnant valves. Fortunately some telltale features are frequently preserved as for example the comparatively large umbo of the palaeolimnadiid conchostracans. Occasionally as in TCT 105 (Pl. 1, fig. 9) evidence of apparent epibionts has not been destroyed totally. Carbonized fossils are restricted to thin films of conchostracan valves (UT 12F), fragmentary plants and one malacostracan shield.

Lithologies

Shales and sandstone are dominant. Shales include: laminated gray (Knocklofty) and hard, tan (Poatina) varieties. The sandstones are either conglomeratic, buff or tan (Cascades, Conningham, Knocklofty) or similar sandstones contain light gray conchostracan-bearing shale chips (Knocklofty) or clay pebbles (Old Beach).

PALAEOECOLOGY

Population Density

Some idea of population density can be obtained by determination of number of valves or valve impressions per given area of a slab. In the Knocklofty Formation at Tinderbox, a slab area of 43 mm x 16 mm contained 21 valves; at Knocklofty, a slab area of 20 mm x 14 mm contained 21 valves, while in the Ross Formation at Poatina, a slab area of 70 mm x 52 mm contained 40 valves. These valves are in close proximity or in coquinoid assemblages on the bedding plane. Obviously since each conchostracan had two valves the actual population count represented by these figures was at least one half the cited number.

There was a greater density per unit area in the Knocklofty area than at Tinderbox, and at both sites than at Poatina during deposition of Ross Sandstone. Such densities-coquinoid assemblages in very small areas, suggest mass death in mini-basins that were probably relicts of evaporating larger basins.

Restricted Biota

Exclusive of the vertebrates-fish, labyrinthodont amphibians, reptile (Cosgriff 1974), the conchostracans, plants and possible epibionts and insect constitute a restricted community. However, this is not unusual for such nonmarine facies.

Number of Generations

To determine number of conchostracan generations one must be able to follow successive occurrences of valves along the vertical or jagged face of a slab. With one exception, the material on hand did not allow for this since fossil conchostracans were confined to single bedding planes. One slab (TCT, Knocklofty, slab 2) had a thickness of 3.15 mm and contained 13 successive generations.

Sedimentation Rate

From the same slab (slab 2) noted above, the average sedimentation rate was determined by dividing number of generations into slab thickness. The rate was 0.24± mm/yr for the Knocklofty site (at Knocklofty). This rate may be taken as probably the right magnitude although variations may be expected, however slight, from one site to another during the time represented by the deposits.

Durations of Water Basins

Living conchostracans cultured in the writer's laboratory and observed in the wild, generally endure for the lifespan of the given water body (pond, lake margin, river floodplain, hoofprint puddles) in which they live. That is, almost up to the time of complete evaporation of such water bodies, conchostracans continue to grow. As the water evaporates they are restricted to still smaller relicts. In old age (over 15 growth bands) there is a slow-down in growth. (The latter is accommodated in calculations by a minus 15 days corrections).

In the present conchostracan assemblage cyziciids with up to 19+ growth bands (Knocklofty Formation at Knocklofty) denote a maximum endurance of any individual at the given site, of 57 days, which corrected as noted above, comes to 42 days. *Palaeolimnadia (Palaeolimnadia)* of the Ross Sandstone at Poatina had a maximum of 12 growth bands and endured 36 days, while another subgenus *P. (Grandilimnadia)* of the Knocklofty at Cascades and Old Beach, had up to 17 growth bands representing 51 minus 15 days, or some 36 days.

From the cited figures it follows that one month to one- and one-half months was the maximum time of endurance for any of the conchostracan-bearing ponds or puddles of this study.

CHANGING COMMUNITY STRUCTURE

In the Ross Sandstone only species of *Palaeolimnadia* subgenus *Grandilimnadia* occur. The possibly younger sequence, the Knocklofty Sandstone and Shale contains this same faunal element as well as a second subgenus, *Palaeolimnadia* and other biotic elements which may be new to the region during the time interval being discussed, *Cyzicus (Lioestheria)* - three species - and *Palaeolimnadiopsis*, as well as a malacostracan genus, possibly insects, epibionts, and plants. No arthropod fossils were found in samples from the higher unit, the Brady Formation, although estheriids have been reported from the Brady (Banks, p. 40 in Williams and Smith 1965).

DISCUSSION

Cosgriff (1974) referred to the Knocklofty-Blina horizon based on fossil amphibians (*Blinasaurus* etc.) from the Lower Triassic of Tasmania. He also noted that the named amphibian was most closely related to *Brachyops* of the Mangli beds of India, among others, and that the horizon "appears to be above the *Lystrosaurus* zone".

Data on Knocklofty conchostracans lend support to the correlation with the Blina Shale. Study of the Blina Shale conchostracans from Canning Basin cores (by the author) show that the Blina and Knocklofty Formations share two genera and three subgenera of conchostracans: *Palaeolimnadia (Palaeolimnadia)*, *Palaeolimnadia (Grandilimnadia)*, *Cyzicus (Lioestheria)*. The Knocklofty shares one genus and subgenus with the Mangli Beds of India, recently studied by the writer and colleagues from the Geological Survey of India, namely *Cyzicus (Lioestheria)*.

The Mangli Beds of India, some 91.5 metres above the *Glossopteris* beds, were placed near the base of the Upper Panchets (with reference to the Triassic section of the Raniganj Coal Basin) (Tasch *et al*.1973). *Lystrosaurus* is abundant in the Upper Panchets but occurs sparsely in the Lower Panchets. Accordingly, if the *Lystrosaurus* zone is taken to designate that portion of the section where that genus is abundant (Upper Panchets) then the Mangli Beds are below the *Lystrosaurus* zone. If the zone is taken to include sparse though abundant occurrences, then the Mangli Beds are stratigraphically in the *Lystrosaurus* zone. Either way Cosgriff's inference that "the Knocklofty-Blina horizon appears to be above the *Lystrosaurus* zone" needs modification. (Cf. Tripathi and Satsangi 1963).

Another view is sponsored by the finding of a palaeolimnadid, some 36 metres above the *Schizoneura-Glossopteris* transition zone in the Lower Panchets (Raniganj Basin) (Data in Tasch *et al*. 1973). This paleolimnadid horizon is quite likely the equivalent of the palaeolimnadid bed of the Tasmanian Knocklofty Formation. That would place it well below the Mangli Beds in the basal Upper Panchets. Following this correlation the *Brachyops* of the Mangli Beds then occur stratigraphically higher (i.e. *geologically younger*) than the Knocklofty labyrinthodonts of Cosgriff.

PALAEOLIMNADID CONCHOSTRACAN CORRELATIONS

Presence of Triassic palaeolimnadid conchostracans in eastern Australia (Bowen and Sydney Basins) and Western Australia (Bonaparte Gulf and Canning Basins) as well as in the Ross Sandstone and Knocklofty Formation of Tasmania, and in the Lower Panchets (Raniganj Basin) of India indicates comparative proximity of West Australia to India. It also shows dispersal between eastern Australia and Tasmania and between Western and eastern Australia during Triassic time.

Cosgriff (1974) noted that in addition to vertebrate fossil evidence, palynological evidence supports the close synchroneity of the Knocklofty and Blina Formations (the latter from the Canning Basin of Western Australia). This paper brings independent evidence of a third kind - nonmarine palaeolimnadid conchostracans, in support of this correlation.

The origin of the Tasmanian palaeolimnadids was probably in the eastern Australian Triassic basins. Palaeolimnadid eggs could have been dispersed from eastern to Western Australia by a series of freshwater "stepping stones". The proximity of India and Western Australia would then explain the Indian Raniganj Basin occurrence.

SYSTEMATIC PALAEONTOLOGY

Cyzicus Audouin, 1837

Cyzicus (Lioestheria) sp. 1

Diagnosis: subovate valves; umbo situated closer to anterior side: hachure type markings on growth bands.
Material: Slab No. 54662 contains some 21 similar valves. Excepting the two valves noted below under "Measurements", all others are in close proximity. However, these are poorly preserved as carbonized films and eroded both over the centre of the valve and the umbonal region. Not figured.

Measurements:

Specimen No.	Valve	Length (mm) (l)	Height (mm) (h)	h/l	a*	p**
UT 12 F, 1	Right	2.70	2.10	0.77	15	25
UT 12 F, 2	Left	2.70	1.95	0.72	15	15

*antero-dorsal angle, **postero-dorsal angle.
Locality: Knocklofty Formation, Tinderbox Bay.

Cyzicus (Lioestheria) sp. 2

(Pl. 1, fig. 3)

Diagnosis: narrowly ovate; umbo, subterminal; dorsal margin straight; ornamentation punctate.
Material: A pair of valves are present; the upper being the left valve and obscuring most of the underlying right valve. Both valves are carbonized. Slab 54664, UT 11.
Measurements: Length = 4.05 mm; height = 2.70 mm; h/l = 0.66, antero-dorsal angle = 30°; postero-dorsal angle = 65°; ratio of length of valve (l_v) to length of dorsal margin (l_{dm}) = 0.52. Growth bands, 16+ (eroded on umbonal sector).
Discussion: Distinguished from *C. (Lio.)* sp. 1 by overall configuration, punctate ornamentation; and antero- and postero-dorsal angles; from *C. (Lio.)* sp. 3, by a smaller l_v/l_{dm} ratio and overall configuration.
Locality: Knocklofty Formation, Knocklofty.

Cyzicus (Lioestheria) sp. 3

(P. 1, fig. 11)

Diagnosis: broadly ovate valve, truncated by a straight dorsal margin; umbo subterminal; ornamentation punctate.
Measurement: length 4.05 mm.
Material: carbonized, flattened impression of a single left valve. UT 10, Slab 54664.
Locality: Knocklofty Formation, Knocklofty.
Discussion: differs from *C. (Lio.)* sp. 1 in overall configuration and ornamentation.

Palaeolimnadia Raymond, 1946

The genus is divided into two subgenera to accommodate the natural groupings of specimens found in the Canning Basin and elsewhere. The two genera are defined as: *Palaeolimnadia (Palaeolimnadia)*, with few growth bands, and h/l ratio of 0.82±, and *Palaeolimnadia (Grandilmnadia)* with few-to-numerous growth bands and h/l of 0.63±.

Palaeolimnadia (Palaeolimnadia) cf. *wianamattensis* Mitchell, 1927

(Pl. 1, fig. 6)

Diagnosis: ovate palaeolimnadid with large round umbo greater than fifty percent the total length of valve; with comparatively few growth bands.
Material: posterior third of left valve covered; median sector to ventral margin, crushed (UT 28, Slab 88059).
Measurements: length 1.80 mm; height 1.35 mm; h/l = 0.75±; length of umbo (l_u) 1.20 mm, height of umbo (h_u) 1.05 mm; h_u/l_u = 0.87.
Discussion: While incomplete preservation prevents species description, the large umbo and few growth bands suffice to place the genus and subgenus. The h/l ratio falls close to that for *Palaeolimnadia (Palaeolimnadia) wianamattensis* Mitchell, 1927 (fig.

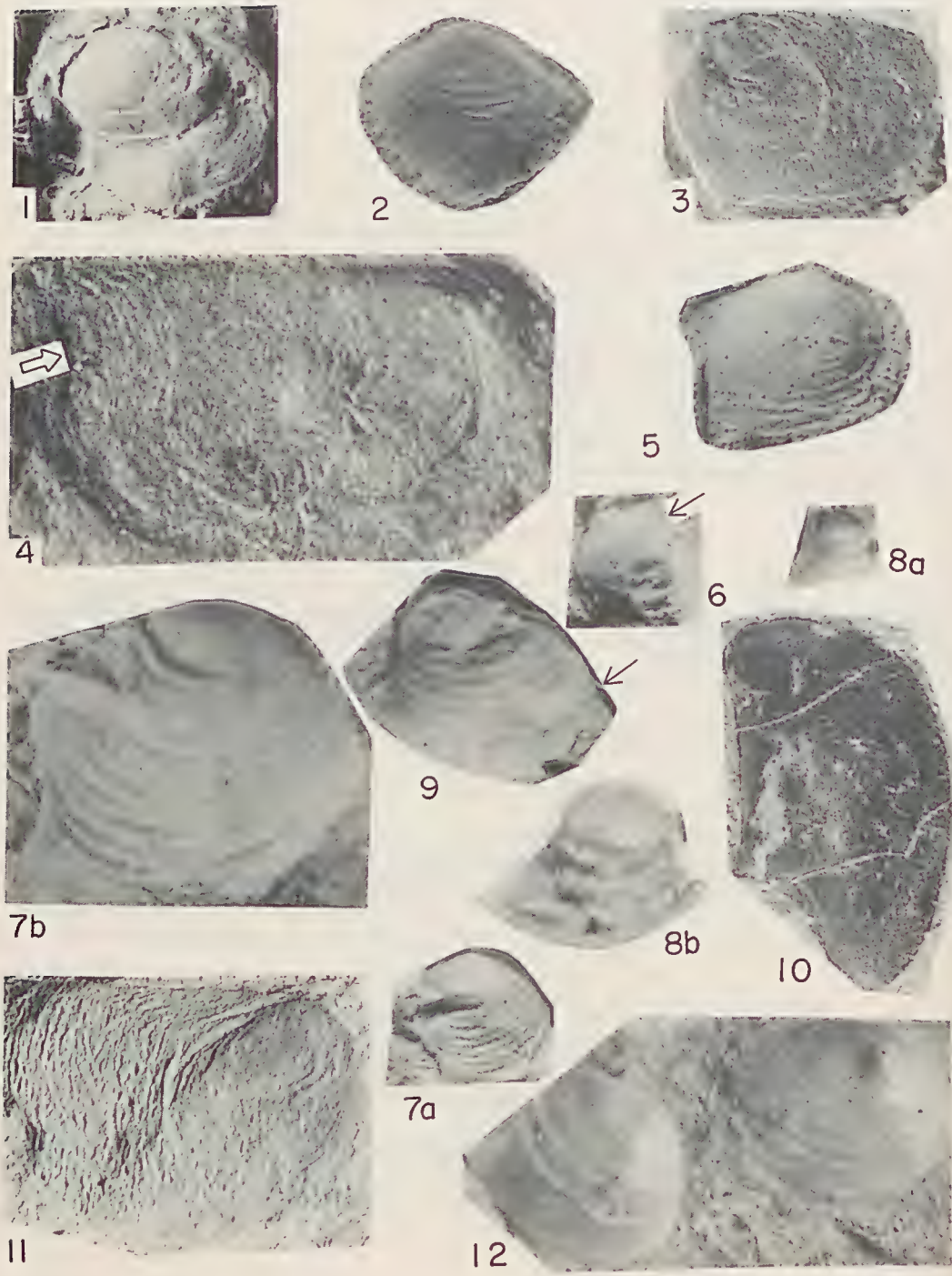
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PLATE 1

Explanation of Figures

Fig. 1: *Palaeolimnadia (Grandilimnadia)* sp. 1. Knocklofty Formation, Cascades, UT-14, Slab 88059; left valve, height 2.55 mm.

Fig. 2: *Palaeolimnadia (Palaeolimnadia) poatinis* n. sp. Holotype. Ross Sandstone, Poatina, UT-3, Slab 55663; right valve, note elliptical umbo, length 2.10 mm.

Fig. 3: *Cyzicus (Lioestheria)* sp. 2. Knocklofty Formation, Knocklofty, UT-11, Slab 54664; a pair of carbonized valves; upper, left valve, length 4.05 mm.

Fig. 4: *Palaeolimnadopsis tasmanii* n. sp. Holotype. Knocklofty Formation, Tinderbox Bay, UT-9, Slab 54662; arrow points to posterior recurvature of last 4-5 growth bands, length 5.10 mm.

Fig. 5; 12: *Palaeolimnadia (Palaeolimnadia) banksia* n. sp. 5, Holotype. Ross Sandstone, Poatina, UT-80, Slab 54665; right valve with large umbo and nine growth bands, length 2.70 mm : 12, Paratype. Ross Sandstone, Poatina, UT-6, 1, Slab 54665B; two right valves; one with apparent node or spine (an artifact of uneven crushing), length 2.40 mm.

Fig. 6: *Palaeolimnadia (Palaeolimnadia)* cf *wianamattensis* Mitchell, 1927. Knocklofty Formation, Cascades, UT-28, Slab 88059; left valve, with umbo greater than 50 percent of valve length and few growth bands, arrow points to umbo, length 1.80 mm.

Fig. 7: *Palaeolimnadia (Palaeolimnadia)* sp. 1. Knocklofty Formation, Cascades, UT-40, Slab 88059. a, right valve, height 1.57 mm; b, Same, X40.

Fig. 8: *Palaeolimnadia* sp. Knocklofty Formation, Old Beach, in conglomeratic lens in sandstone, TUT, 105; Subgenus undetermined due to fragmentary preservation, but note typical, large, palaeolimnadid umbo; a, length of umbo 0.47 mm; b, same, greatly enlarged to show configuration and size of umbo.

Fig. 9: Palaeolimnadid right valve impression, bearing evidence of probable epibionts (worm borings) represented by white streaks; and negative of arthropod beaded fecal string (arrow); Knocklofty Formation, Crisp and Gunns Quarry, Knocklofty; TUT-105; length 1.6 mm.

Fig. 10: Probable malacostracan carbonized carapace valve (articulation to a left carapace valve in life inferred); Knocklofty Formation, Crisp and Gunn Quarry, Knocklofty; UT, Slab 93983; length 7.50 mm.

Fig. 11: *Cyzicus (Lioestheria)* sp. 3. Note broad ovate configuration. Knocklofty Formation, Knocklofty; UT-10, Slab 54664; length 4.05 mm.

8 only) but differs from it in being a rounded umbo as contrasted to the ovate umbo in Mitchell's species.
Locality: Knocklofty Formation, Cascades.

Palaeolomnadia (Palaeolimnadia) banksia n. sp.

(Pl. 1, figs. 5, 12)

Diagnosis: ovate to subovate, very convex valves with large umbo; nine or less growth bands.
Material: A porous sandstone slab contains an eccentrically ovate light gray shale chip (34 mm x 18 mm) bearing 40+ conchostracan valve impressions, including seven of the new species (Slab 54663B). Another slab with a light gray shale chip (Slab 54665) contains one complete specimen (UT 80), and one incomplete specimen (UT 81).
Measurements:

Slab #	Type	Specimen No.	length (mm)	height (mm)	h/l	l_u	h_u	h_u/l_u	G-B*	a	p
54665	Holotype	UT 80	2.70	2.10	0.77	1.20	0.75	0.62	9	35°	15°
54663B	Paratype**	UT 6, 1	2.40	1.95	0.81	1.08	0.58	0.53	6	30°	15°
54663B	Paratype	UT 6, 4	2.08	1.60	0.77	1.20	0.66	0.55	4	30°	15°

*G-B = growth bands

**Apparent spine is a pseudostructure due to uneven crushing of valve.

Name: The species name is for Mr. Max Banks, University of Tasmania.
Locality: Ross Sandstone, Poatina.

Palaeolimnadia (Palaeolimnadia) poatinis n. sp.

(Pl. 1, fig. 2)

Diagnosis: subovate valve with comparatively large elliptical umbo and ten growth bands.
Material: impression of right valve, UT 3, slab 55663.
Measurements: length 2.70 mm, height 2.10 mm, h/l = 0.77; length of umbo 1.0 mm, height of umbo 0.47 mm, h_u/l_u = 0.47; antero-dorsal angle 45°; postero-dorsal angle 30°.
Discussion: This species differs from *P. (P.) banksia* in larger antero-and postero-dorsal angles, and smaller h_u/l_u ratio, while sharing the same h/l ratio. It differs from *P. (P.) vianamattensis* chiefly in umbonal ratio h_u/l_u being markedly smaller in the new species.
Locality: Ross Sandstone, Poatina.

Palaeolimnadia (Palaeolimnadia) sp. 1

(Pl. 1, figs. 7a, 7b)

Diagnosis: very convex, sub-round palaeolimnadid with comparatively large umbo and 12 growth bands.
Material: right valve that is crushed in median sector, eroded along posterior and postero-dorsal margins. UT 40, slab 88059.
Measurements: length 1.95 mm, height 1.57 mm; h/l = 0.80; length of umbo 0.37 mm, height of umbo 0.53 mm, antero-dorsal angle 30°.
Discussion: this species based on measured parameters is closest to *P. (P.) banksia*, but poor preservation prevents a clearcut determination.
Locality: Knocklofty Formation, Cascades.

Palaeolimnadia (Grandilimnadia) sp. 1

(Pl. 1, fig. 1)

Diagnosis: broadly ovate valve with large elliptical umbo situated closer to anterior end; straight dorsal margin that sharply arches posteriorly; variable growth band number to 17+.
Material: specimens include one crushed left valve (UT 14) and a right valve with anterior and dorsal margins covered (UT 25). Slab 88059.
Measurements: Length 3.75 mm, height 2.55 mm; h/l = 0.68; h_u/l_u = 0.90.
Locality: Knocklofty Formation, Cascades and Old Beach.

Palaeolimnadopsis tasmanii n. sp.

(Pl. 1, fig. 4)

Diagnosis: oblong valves with gentle posterior recurvature visible on last 4-5 growth bands; postero-dorsal margin obscure; umbo subcentral, and situated below straight dorsal margin; last ten growth bands tightly spaced.
Material: a single specimen retaining distinctive features, eroded and crushed. UT 9, slab 54662.
Measurements: Length 5.10 mm, height 3.00 mm; h/l = 0.58; length of dorsal margin (l_{dm}) 3.95 mm; l_{dm}/l = 0.77.
Discussion: Palaeolimnadopsids are known from the Carboniferous to the Cretaceous. They occur in the lower Triassic of Germany, the Kouznetsk Basin, and the Volga River (Vetlouga Stage). The Tasmanian species differs from *P. brevis* (Volga River) in configuration and antero-dorsal angle; from *P. alberti* (Germany and U.S.S.R.) in its oblong configuration and h/l ratio, although the ratio l_{dm}/l corresponds to that of one of the U.S.S.R. specimens (Novojilov, 1955, pl. 1, fig. 11, Specimen No. 1322 (5). Furthermore the posterior recurvature of growth bands is much more pronounced in the Tasmanian species.
Locality: Knocklofty Formation, Tinderbox Bay.

Class Malacostraca

Subclass, Order, and Family Uncertain

(Pl. 1, fig. 10)

Diagnosis: carapace valves subovate, feebly arched at midline, presumably separable at median hingeline; arcuate posterior notch; valves with marginal posterior ridge; slightly elevated with valve face raised above gentle slopes at hingeline and anterior margin, and a lateral, marginal, flat flange; faint growth bands about periphery of valves, and longitudinal markings on inner face of fragmentary valve; complete valve bears minute pustules.
Material: two carbonized valves, one complete, one fragmentary, eroded and the inner face exposed: two slabs, UT 93983.
Measurements: complete valve: length (anterior to posterior arc) 7.50 mm; width 4.05 mm; length of posterior valve horn 2.55 mm.
Discussion: The lack of definitive carapace structures of known malacostracan suborders (inferred median hingeline, the exception) disallows taxonomic placement of these fossil valves. The arcuate posterior notch, and rounded anterior, has many parallels among malacostracans. It should be observed that the two valves occur on separate slabs, and the carapace arrangement in life, is inferred.
Locality: Knocklofty Formation, Knocklofty (Crisp and Gunn Quarry, top of Arthur Street, Hobart).

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THE BASAL BEDS OF THE JUNEE GROUP

by A.V. Brown, N.J. Turner, and E. Williams

Geological Survey of Tasmania

ABSTRACT

The recent redescription by Corbett and Banks (1974) of the geology of Lewis's type area of the Tyenna Valley for the Junee Group is commended. However, the introduction of correlations of rock sequences from localities over 24 km apart into a proposed definition of the Junee Group contravenes the Australian Code of Stratigraphic Nomenclature, and is therefore invalid. The correlations of the basal beds of the Junee Group discussed by Corbett and Banks are controversial.

INTRODUCTION

In his study of the geology of the Tyenna Valley, Lewis (1940) established conformable relationships between units of an extensive group of rocks which he termed the Junee Series. Lewis (p. 47-48) summarised the "sequence in the type area.....

4. Diastrophic break.
3. Junee Series (iii) Blue Junee limestone.
   (ii) Yellow mudstone containing trilobites and other fossils of lower ordovician age.
   (i) Quartzites with conglomerates and breccias interbedded.
2. Probable unconformity".

Hills and Carey (1949, p. 24-28) referred to Lewis's sequence as the Junee Group which they defined in terms of rock units from widely dispersed localities in western and northern Tasmania. The use of the term "Junee Group" in a Tasmania-wide context is common practice (e.g. Banks 1962, p. 147), but members of the Geological Survey of Tasmania have long held the view that the type area of the Group is that of Lewis in the Tyenna Valley (e.g. Williams in Jennings *et al.* 1967, pp. 13-15), and have referred to correlates elsewhere as "Junee Group Correlates" (e.g. Williams and Turner 1974; Geological Atlas 1:250 000 series, in press; Williams, Solomon and Green in press).

In a recent paper Corbett and Banks (1974) redescribed the Junee Group in the type area of Lewis, and excluded from the Group Precambrian dolomite and quartzite sequences that had been clearly inadvertently incorporated by Lewis into his "Quartzites with conglomerates and breccias interbedded". At Tim Shea, Corbett and Banks (1974, p. 216) described Lewis's "Quartzites with conglomerates and breccias interbedded" as the Tim Shea Sandstone consisting of up to 300 m of shallow-water red to grey quartzose sandstone, minor conglomerate, red siltstone, and with dolomitic sandstone and locally derived breccia at the base unconformably on Precambrian dolomite.

JUNEE GROUP CORRELATES

In the Adam River Falls area, some 14 km to the west of Lewis's type area, Nye (1929, p. 10-11) described as one unit "several hundred feet at least.....conglomerates, grits and quartzites" which overlie unconformably "slates, cherts and fine-grained breccia". Lewis (p. 49), although aware of the pitfalls of litho-stratigraphic correlations across little known country, drew attention to the 'very close resemblance' between the quartz-rich rock unit with its geological relationships in

the Adam River Falls area and the Tim Shea quartz-rich sequence, and he postulated that his "Junee Series" extended from the type area into the Adam River Falls region.

In a current mapping programme of the Huntley Quadrangle the writers consider the shallow-water and terrestrial quartz-rich sequences of the Adam River Falls area to be associated in a single unit, as did Nye (1929, p. 11), although members of predominantly quartzose sandstone and predominantly quartzose conglomerate are being mapped separately, and they correlate the quartz-rich unit with the Tim Shea Sandstone. In contrast, Corbett and Banks (1974, fig. 1) correlated a transitional boundary between a lower quartzose sandstone member and an overlying predominantly quartzose conglomerate member within the single quartz-rich unit of Nye with the base of the Junee Group. Similarly, in the Reeds Peak area, some 24 km north-west of Lewis's type area, Corbett and Banks (1974, p. 214) excluded a lower shallow-water quartzose sandstone sequence from correlations made with the Junee Group of the type area, and correlate a transitional boundary between the lower quartzose sandstone sequence and an overlying predominantly quartzose conglomerate with the base of the Junee Group. Obviously, since the Tim Shea Sandstone has not been (or cannot be, see Corbett and Banks, p. 214 and fig. 1) 'walked' from Tim Shea to the Adam River Falls or Reeds Peak, there is an element of doubt in the correlations. Differences of opinion in correlations, however, obviously cannot affect what constitutes the Junee Group in Lewis's type area. Corbett and Banks (1974, fig. 2) recognise that their discussion of the sequences at Reeds Peak is in terms of correlations with rock units in Lewis's type area. However, it is most unfortunate that the rock successions of Reeds Peak and the suggested correlation with the Tim Shea Sandstone of Lewis's type area are considered by Corbett and Banks to be an essential part of their proposed redefinition of the Junee Group.

DISCUSSION OF JUNEE GROUP DEFINITION

Lewis's ordering of the litho-stratigraphic units in the Tyenna Valley is essentially correct, so that his "Junee" sequence can hardly be discarded, and his clearly stated intentions on its use must be respected. Presumably these comments are acceptable to Corbett and Banks since they have persisted in using the named "Junee" sequence. However, by the introduction of correlations with Reeds Peak successions into the formal definition of the Junee Group, Corbett and Banks appear to have acted contrary to the Code of Stratigraphic Nomenclature, with which they wish to accord (p. 214), for it states in Rule 12 "Rock unit names.....should be 'validated', by later workers *in the same area*....." (authors' italics), and in Rule 36 "The location of the type section of a valid unit may not be changed".

The present writers commend Corbett and Banks for their fine description of the geology of the Florentine Valley in south-west Tasmania and particularly for their redescription of Lewis's type area, but find invalid their introduction of correlations of rock sequences from localities over 24 km apart into the definition of the Junee Group. The invalidity of the proposed definition of Corbett and Banks cannot be changed by attempts to justify correlations. Furthermore, if correlations between the rock sequences at Reeds Peak and the Junee Group of Lewis's type area around Tyenna Valley are in any way controversial or unsatisfactory, the Australian Code of Stratigraphic Nomenclature allows for the creation of a new named group for the rocks of the Reeds Peak area. Hopefully, time-rock units of a fine enough scale will be established in the future which may help in determining more accurate lithostratigraphic correlations between the rock unit of Lewis's type area and rock sequences elsewhere. However, as indicated by Lewis (p. 48), it would be both pointless and unsupportable to attempt to force rock unit terms into a too precise compatibility with the accepted major international time-rock unit terms (e.g. Cambrian System, Ordovician System etc.).

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THE LATE CAMBRIAN TO EARLY ORDOVICIAN SEQUENCE ON THE DENISON RANGE, SOUTHWEST TASMANIA

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(with three text-figures)

ABSTRACT

A well-exposed middle Late Cambrian to Early Ordovician clastic sequence, herein referred to as the Denison Subgroup, unconformably overlies Middle Cambrian rocks on the Denison Range and is conformably overlain by Ordovician limestone. Four formations are recognized. The basal Singing Creek Formation (720 m) consists of interbedded siltstone, quartzwacke turbidites, siliceous fine conglomerate, and slump sheets, and contains an abundant Franconian trilobite-brachiopod fauna. It grades upwards into the Great Dome Sandstone (510 m), a shallow marine-deltaic-fluvial sequence of cross-bedded quartz sandstone, siltstone and fine conglomerate, with a sparse fauna of probable Late Cambrian age. Above this the Reeds Conglomerate (1560 m) comprises largely non-marine pink siliceous conglomerate and cross-bedded sandstone, probably deposited on alluvial fans. This grades into the marine Squirrel Creek Formation, comprising a lower sandstone member (150 m) with worm burrows and gastropods, a siltstone-limestone member (150 m) with an abundant Early Ordovician shelly fauna, and an upper sandstone member (300 m).

The Denison Subgroup is approximately equivalent to the pre-limestone part of the Junee Group in the original area of Lewis, and to the Owen Conglomerate of western Tasmania.

INTRODUCTION

The Denison Range lies some 20 kilometres north of the old mining township of Adamsfield and some 35 kilometres northwest of Maydena, in southwest Tasmania. The area was mapped by the author during 1966-68 as part of a Ph.D. study at the University of Tasmania. Access to the area is possible only by foot or by helicopter, and most of the field work was carried out from a helicopter-supplied camp at Lake Rhona in conjunction with a mineral exploration programme then being conducted by the Broken Hill Proprietary Co. Ltd. Financial assistance was provided by a B.H.P. Postgraduate Scholarship in Geology.

Research was concentrated on the previously unknown Late Cambrian flysch-paralic sequence, and some details of the sedimentology of that sequence have already been published (Corbett 1972, 1973). A general outline of the geology of the area was given in Corbett and Banks (1974), together with details of the Ordovician stratigraphy and palaeontology in adjacent areas. The reader is referred to that paper for the geological setting of the Denison Range sequence. More recently, the Geological Survey of Tasmania has been mapping the areas west and south of the Denison Range, and considerable new information on that area will shortly be available. The only early reference of note on the Denison Range is that of Twelvetrees (1908), who noted the "Cambrian" conglomerates on the main part of the range, with underlying quartzite and overlying limestones, in his exploration of the Great Western Railway route (see summary by Ward 1910).

In an earlier paper (Corbett and Banks 1974) the Reeds Conglomerate was included

in a re-definition of the Junee Group, since it was regarded as a correlate of the Tim Shea Sandstone in the area of Lewis's (1940) original "Junee Series". However, this correlation has been questioned by Brown *et al* (this volume), who argue that the Junee Group should only be defined in Lewis's original area and that correlations to other areas should not be involved. The problem of Junee Group terminology is discussed in a separate paper (Corbett and Banks, this volume), but the Reeds Conglomerate is now included in the Denison Subgroup, which may be regarded as approximately equivalent to the pre-limestone part of the Junee Group.

The stratigraphic succession in the Denison Range area may be summarized as follows (thicknesses estimated):

	Limestone of Gordon Subgroup	700m+
	(Squirrel Creek Formation (Early Ordovician)	600m
Denison	(Reeds Conglomerate	1560m
Subgroup	(Great Dome Sandstone (Late Cambrian ?)	510m
	(Singing Creek Formation (Franconian)	720m
Unconformity		
	Trial Ridge Beds (Middle Cambrian)	500m
Probable unconformity		
	Pyritic phyllite or schist (Precambrian)	

TRIAL RIDGE BEDS

These comprise a sequence of siliceous conglomerate, sandstone and siltstone exposed on Trial Ridge, just west of the Denison Range (fig. 1). The sequence dips fairly uniformly ESE at about 60° over most of the ridge. The beds are truncated by the overlying Singing Creek Formation at the northern end of Trial Ridge, the unconformity being exposed at about E42312, N76167. Here there is an angular discordance in strike of about 20°, the underlying sandstone beds dipping ESE at about 60°, and the overlying basal conglomerate dipping east at about 53°.

Further north, in Kindling Creek, the lower conglomerate of the Trial Ridge Beds overlies a crenulated black pyritic phyllite or quartz-schist, and the contact, although not exposed, is thought to be an unconformity. The rock resembles the crenulated phyllitic rocks which occur within Precambrian sequences elsewhere.

The sequence has a maximum thickness of at least 500 metres, and consists largely of siliceous conglomerate and cross-bedded quartz sandstone in the lower part and of interbedded lithic-quartz wacke and siltstone, with lesser siliceous conglomerate, in the upper part. Some of the sandstone beds in the upper part show graded bedding and erosional sole marks, and may be turbidites.

Fossils have recently been discovered in the Trial Ridge Beds by members of the Geological Survey of Tasmania, and a Middle Cambrian age has been assigned to them (A.V. Brown and N.J. Turner, pers. comm.).

DENISON SUBGROUP

The Denison Subgroup is defined as comprising the Singing Creek Formation, Great Dome Sandstone, Reeds Conglomerate, and Squirrel Creek Formation, as defined below. It has a total thickness of about 3390 metres, and ranges in age from middle Late Cambrian to Early Ordovician. The bulk of the sequence comprises a Late Cambrian regression from marine proximal flysch facies through shallow marine, deltaic and fluvial sandstones to non-marine fanglomerate, while the upper part represents an Early Ordovician transgression. Virtually all the clastic material is of Precambrian origin, and the current direction data indicate derivation from the Tyennan Nucleus just to the west.

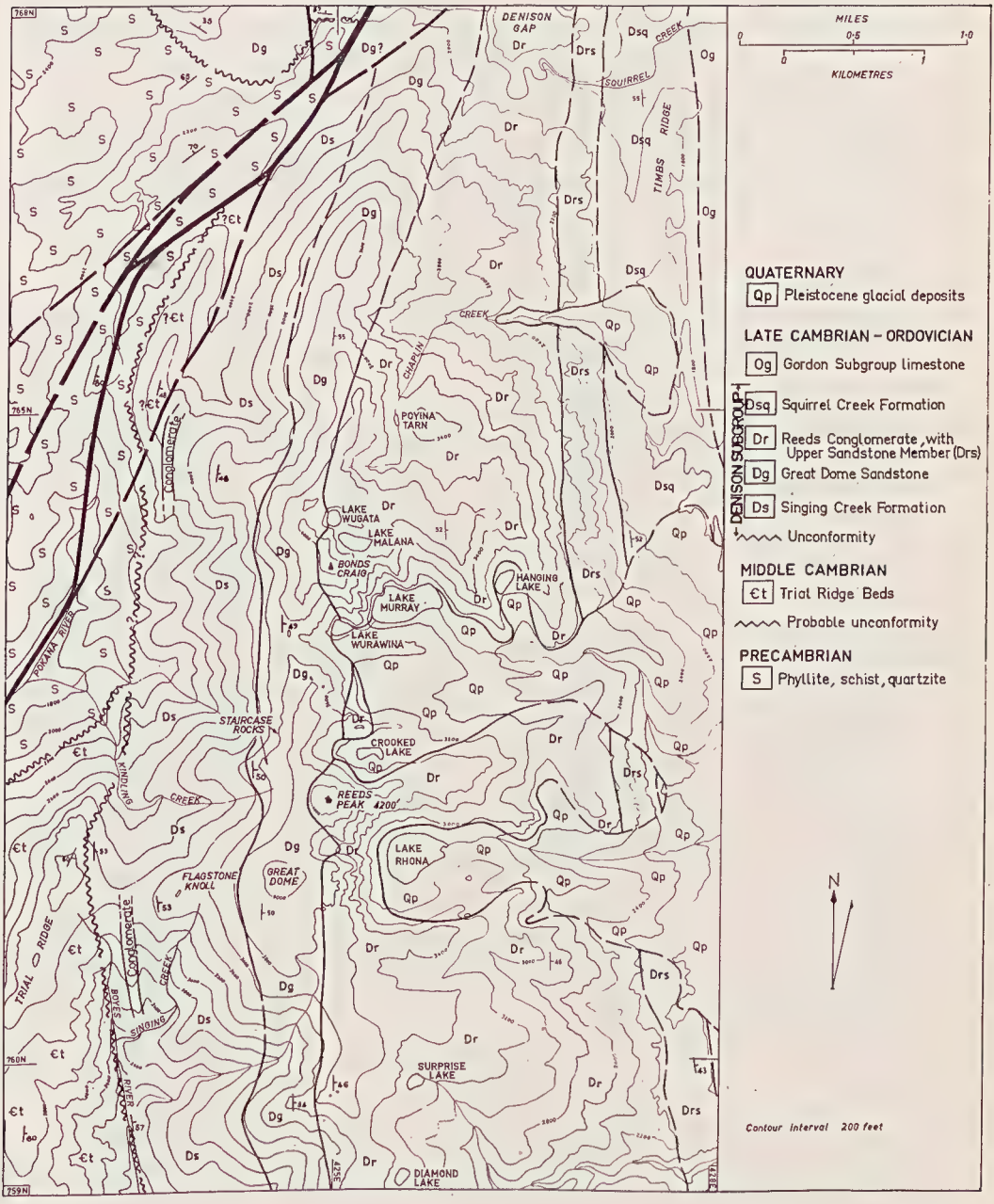

FIG. 1. - Geology of the central and northern parts of the Denison Range (after Corbett 1970).

Late Cambrian to Early Ordovician Sequence, Denison Range

The Denison Range area was apparently the deepest part of the Late Cambrian basin, and the lower marine formations wedge out progressively to the north and to the south and east. The Singing Creek Formation is apparently not represented at Tim Shea, in the type area of Lewis's original "Junee Series", and further east towards Maydena the base of the section comprises pebbly sandstone of probable Early Ordovician age (M.R. Banks, *pers. comm.*). The basal unconformity on the Denison Range, however, appears to be the same as that forming the base of the "Junee Series" in the Tim Shea area (see Corbett and Banks, this volume). Thus the Denison Subgroup may be considered as representing the expanded and more complete section between the Gordon Subgroup limestones and the basal unconformity of the Junee Group. It corresponds to the "Denison Range conglomerates and quartzites" of Ward (1910, p. 127).

SINGING CREEK FORMATION

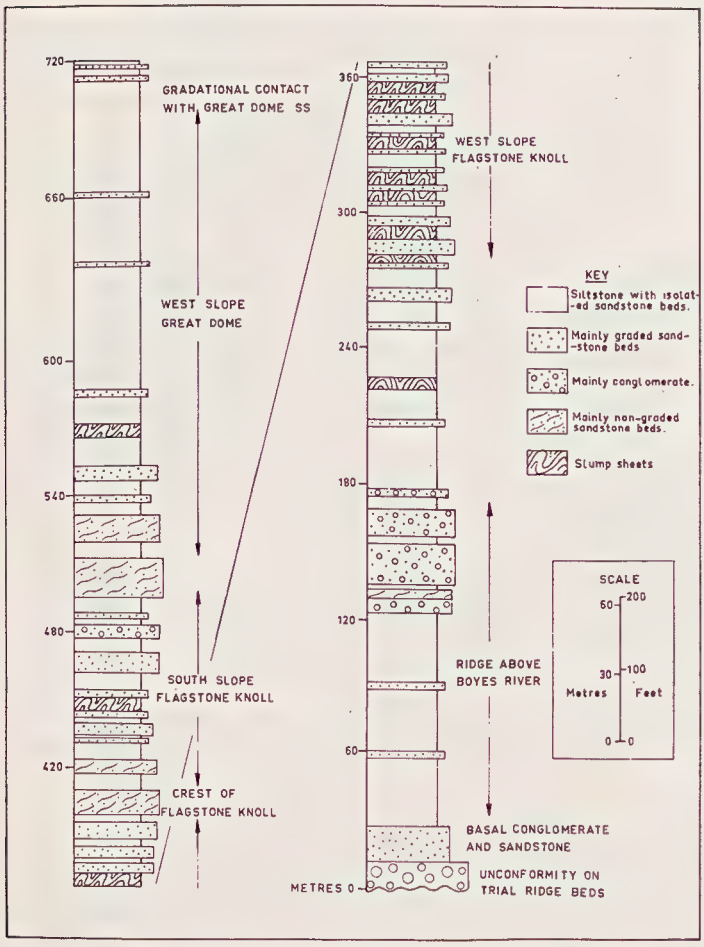

FIG. 2. - Composite section of Singing Creek Formation.

This comprises some 720 metres of interbedded quartzwacke sandstone, laminated micaceous siltstone, siliceous conglomerate and slump sheets. The base is the unconformity on the Trial Ridge Beds, and the top is a conformable gradation into Great Dome Sandstone exposed at Staircase Rocks (fig. 1). The sequence dips uniformly east at 45°-55° and is apparently free of tectonic cleavage.

No single complete type section is available. A composite but partly diagrammatic section (fig. 2) has been compiled from exposures near Trial Ridge, in Singing Creek, on Flagstone Knoll, on the west flank of Great Dome and at Staircase Rocks. Fawn-weathering grey laminated siltstone and silty fine sandstone forms the basis of the formation and occurs as more or less pure sequences at the top and near the base. Pale grey, white-weathering quartzwacke sandstone occurs as single beds and as composite units up to 25 metres thick. Granule to cobble grade siliceous conglomerate beds occur sporadically through the sequence, and form a basal unit and another on a small ridge just east of the upper Boyes River. Slump sheets, including pebbly mudstones, up to several metres thick, are abundant in parts of the section (Corbett 1973).

Depositional environment:- Many of the thinner sandstone beds (up to 30 cm) show grading, and nearly all have sharp bases. Sole marks are common, and include longitudinal ridges, obstacle scours, tool marks, flute marks, channels and load marks. Many beds show a sequence of internal structures from a basal structureless division followed by a division of parallel lamination, a division of cross-lamination, and an upper division of laminated siltstone. The features correspond to those of classical turbidites as described by Bouma (1962). There are also thicker (up to 2 m) non-graded sandstone beds, some of which show dish structures, wavey lamination and elutriation columns. These rocks have been described previously (Corbett 1972) and interpreted as also being turbidity current deposits.

The composite sandstone and sandstone-conglomerate sequences are interpreted as being channel deposits, at least in part, and the formation as a whole is thought to represent a submarine fan complex (Corbett 1970). Measurement of 67 flutes and parting lineations indicates currents from the west, and this together with other provenance indicators, particularly the abundance of Precambrian detritus, indicates derivation from the Tyennan Nucleus.

Palaeontology:- Siltstone and fine sandstone beds in the lower, middle and upper parts of the formation contain a marine fauna of trilobites, articulate and inarticulate brachiopods, rare gastropods, and numerous trace fossils. The most common trilobites are *Proceratopyge* sp. and *Pseudagnostus* sp., and the fauna includes several new agnostid species and genera, and a form like *Sigmocheilus* sp. (J.B. Jago, *pers. comm.*). Articulate brachiopods include *Billingsella* cf *corrugata*, *Billingsella* sp. nov., and a form like *Jamesella* sp., and the inarticulates include *Lingulella* cf *perattenuata*, a form like *Pseudodicellomus* sp., and a form like *Palaeobolus* sp. (M.R. Banks, *pers. comm.*). Banks suggests a lower Franconian age (probably *Elvinia* Zone), and Jago suggests an *Elvinia* Zone or *Conaspis* Zone age.

Correlates of the Singing Creek Formation:- A correlate on the west flank of the Stepped Hills includes siltstone, quartzwacke sandstone and siliceous fine conglomerate. Trilobites, inarticulate and articulate brachiopods (including *Billingsella* sp.), gastropods, bivalves and trace fossils occur in these beds. At Adamsfield, a sequence of serpentinitic conglomerate, calcareous sandstone, siltstone and impure limestone, which unconformably overlies the Adamsfield ultramafic body (Corbett 1970), contains an abundant marine fauna of Late Cambrian age (Upper Dresbachian-Lower Franconian, Opik, in Banks 1962) and may be equivalent to the Singing Creek Formation. There is no apparent correlate of the formation on the Ragged Range. To the north, the formation apparently wedges out against a major fault zone between the Denison Range and Battlement Hills, and is not present west of this fault.

In western Tasmania, a correlate occurs in the Tyndall Range area, where a marine sequence of siltstone, quartzwacke sandstone, and siliceous conglomerate forms the lower part of the Owen Conglomerate correlate (Corbett in press). This sequence is sedimentologically similar to the Singing Creek Formation, and contains a middle Late Cambrian trilobite fauna with major elements in common with the Singing Creek fauna (particularly *Proceratopyge* sp. and *Pseudagnostus* sp.). The fauna is probably of Franconian age (J.B. Jago, *pers. comm.*).

Great Dome Sandstone

This comprises some 510 metres of grey quartzose sandstone, conglomeratic sandstone, fine conglomerate and micaceous siltstone exposed on the west flank of the Denison Range between Staircase Rocks and Reeds Peak (fig. 1). The base at Staircase Rocks (E42429, N76226) is transitional downwards through some ten metres of interbedded sandstone and siltstone to siltstone of the Singing Creek Formation. The top is exposed in the ravine about 150 metres south of Reeds Peak, and is marked by a transition from grey conglomeratic sandstone to pink siliceous conglomerate. A gastropod from the lower part of the formation has been tentatively identified as *Kobayashiella* sp. by Mr. M.R. Banks (*pers. comm.*), suggesting a Late Cambrian age.

Late Cambrian to Early Ordovician Sequence, Denison Range

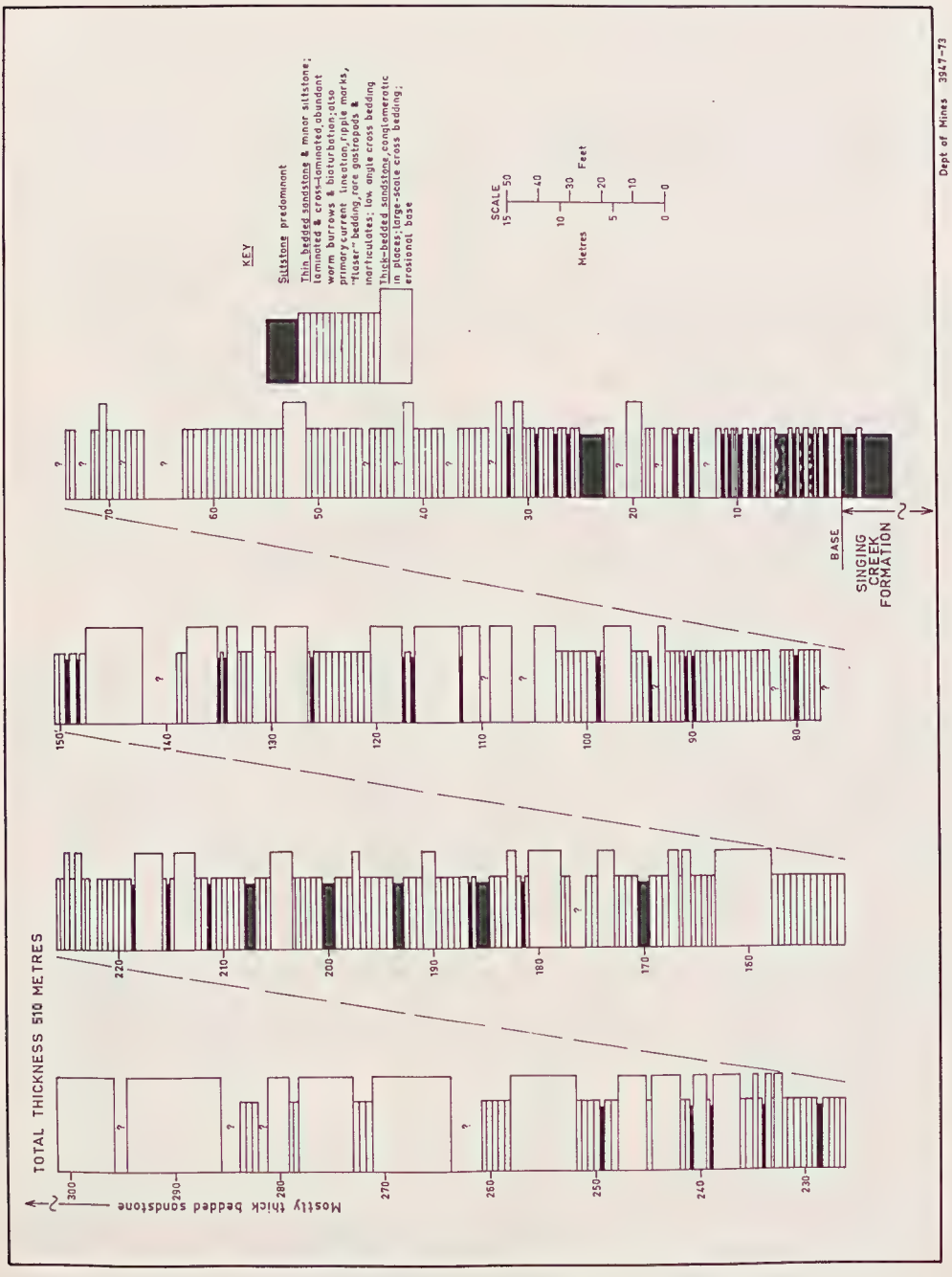
KEY
Siltstone predominant
Thin bedded sandstone & minor siltstone; laminated & cross-laminated, abundant worm burrows & bioturbation; also primary current lineation, ripple marks, hummocky cross-bedding, rare gastropods & inarticulates; low angle cross bedding
Thick-bedded sandstone, conglomeratic in places; large-scale cross bedding; erosional base
SCALE
Metres
Feet
BASE
SINGING CREEK FORMATION
TOTAL THICKNESS 510 METRES
Mostly thick bedded sandstone
Dept of Mines 3947-73

FIG. 3. - Section through lower part ("cyclic facies") of Great Dome Sandstone, Staircase Rocks area.

The lower 250 metres or so of the formation shows a characteristic alternation of white coarse sandstone units, up to six metres thick, and thin-bedded sandstone-siltstone units up to 15 metres thick (fig. 3). The coarse units crop out strongly to form a series of parallel steps or ridges, and typically show large-scale trough cross-bedding and have channelled bases. They are interpreted as meandering distributary channel and tidal channel deposits (Corbett 1970).

The thin-bedded zones, which may include dark micaceous siltstone units up to 1.5 metres thick, show a variety of sedimentary structures including cross-bedding and cross-lamination of several kinds, low-angle (beach-type) cross-bedding, ripple marks, flat lamination with parting lineation, current crescents, large and small pseudonodules, channel structures and deformed lamination. Bioturbation is common, some beds up to a metre thick having been completely reworked. Trace fossils are abundant, particularly vertical and U-shaped burrows. Rare gastropods and small inarticulate brachiopods occur at some horizons. A vertical sequence of lithofacies can be demonstrated in some of the thin-bedded zones, and the interpreted environments include low and high tidal flats, lagoons, barrier beaches and surf zones. The cyclic sequence as a whole appears to represent a complex, tidally-influenced delta-platform deposit (Corbett 1970).

The upper half of the formation consists mainly of grey, cross-bedded quartzose coarse sandstone, conglomeratic sandstone and fine conglomerate, with only thin intercalations of thin-bedded sandstone-siltstone and bioturbated sandstone. This section is interpreted as a delta floodplain deposit with minor marine influence. Most of the upper half of the formation is red in colour in the area west of Bonds Craig, but reverts to grey near the top.

Correlates of the Great Dome Sandstone:- A correlate in the Battlement Hills area overlies a coarse, locally-derived breccia which rests unconformably on Precambrian rocks (first noted by Twelvetrees 1908). The sequence here consists of cross-bedded quartzose sandstone with bioturbated flaggy sandstone. It has a maximum thickness of about 180 metres but thins rapidly to the northwest and is overlapped by conglomerate.

A correlate on Stepped Hills is about 300 metres thick, and comprises cross-bedded sandstone, flaggy sandstone, minor siltstone and minor glauconitic sandstone. A few inarticulate brachiopods and gastropods occur in this sequence. Similar rocks, with bioturbated sandstone beds, occur in the Gordon River at the northwest foot of Clear Hill, and on the adjacent slopes of Clear Hill.

A correlate on the upper western slopes of the Ragged Range is some 180 metres thick, and comprises basal chert-rich conglomerate followed by interbedded quartzose sandstone, micaceous siltstone and haematitic siltstone. The sequence here is unconformable on older Cambrian chert, greywacke and mudstone (Corbett 1970). At Adamsfield, a correlate is exposed in two small reservoirs on Packers Ridge, and comprises a sequence of thin-bedded sandstone, siltstone and pebble conglomerate, with abundant worm burrows as well as gastropods, inarticulate brachiopods and very rare trilobites. Detrital chromite is common through the sequence.

Reeds Conglomerate

This has been previously defined by Corbett and Banks (1974) as "the formation of quartzose conglomerate and conglomeratic sandstone, usually red to purplish in colour, occurring on the crest and eastern slopes of the Denison Range. It has a maximum thickness of about 1560 metres.....". The base may be taken as the change from grey sandstone to pink conglomerate which occurs in the ravine 150 metres south of Reeds Peak. The top is formed by the Upper Sandstone Member. The age of the formation is not known, but as the overlying unit is Early Ordovician and the underlying unit Late Cambrian, it probably spans the Cambrian-Ordovician boundary.

The conglomerate sequence dips uniformly east at about 50°. Rapid variations from pebble conglomerate to conglomeratic sandstone and sandstone are typical, and there are larger-scale alternations of conglomerate-rich and sandstone-rich units. Clasts are typically well rounded, with moderate to high sphericity, and composed dominantly of either quartzite or quartz-schist. Maximum clast size is about 20 cm (cobbles), the majority being less than 10 cm.

The Upper Sandstone Member (fig. 1) occurs along the lower eastern slopes of the range, and is a sequence of grey to pale pink quartzose sandstone, granule conglomerate and pebble conglomerate about 100 metres thick. Its base is transitional to relatively thick-bedded pebble conglomerate, and coincides with a flattening of the slope about 450 metres east of Hanging Lake. The contact with the overlying Squirrel Creek Formation is marked by the appearance of flat-bedded white sandstone with worm burrows on the lower dip slopes east of the above. Complex trough cross-bedding is prominent in most outcrops, and there is a tendency towards columnar weathering in the sandstone beds. A correlate of the member occurs in the Battlement Hills area, where it consists largely of granule to pebble conglomerate. To the south, a correlate of the Member forms the crest and eastern slopes of the Stepped Hills and appears also to be present on Mt. Wright, the east flank of Clear Hill, and along the Saw Back Range (Corbett 1970).

Depositional environment and palaeogeography:- Sedimentary structures in the Reeds Conglomerate include abundant channels and trough cross-bedding in the sandstone and fine conglomerate, and thick bedding with rare large channel structures and large-scale, heterogeneous cross-bedding in the coarser conglomerates. Imbrication of discoidal clasts is apparent in some outcrops. The sedimentary features suggest deposition largely by braided streams, probably on large alluvial fans (see Corbett and Banks 1974, for further discussion). Cross-bedding measurements indicate a westerly derivation, and the predominance of quartzite and quartz-schist clasts indicates that the Tyennan Nucleus was the main source area.

Correlates of the Reeds Conglomerate:- The formation can be traced from northwest of Battlement Hills through the Denison Range, Stepped Hills etc. to the Ragged Range and Saw Back Range in the south. The great thickness variations over this area are outlined in Corbett and Banks (1974). The formation was considered to be laterally equivalent to the Tim Shea Sandstone (*ibid*), which occurs to the southeast, but this is not provable and that formation may also include correlates of the Great Dome Sandstone, as suggested by Brown *et al.* (this volume).

The formation is only partially equivalent to the Owen Conglomerate of western Tasmania. That formation, as defined by Wade and Solomon (1958), includes fossiliferous sandstone of probable Early Ordovician age in the upper part, which is therefore a correlate of the Squirrel Creek Formation in this area. The base of the Owen Conglomerate, although unfossiliferous in most areas, contains middle Late Cambrian fossils in what is apparently a local marine facies near the Tyndall Range (Corbett in press), and this part of the formation is a correlate both lithologically and palaeontologically, with the Singing Creek Formation. Thus the Owen Formation is apparently equivalent to the entire Denison Subgroup from the basal unconformity to the base of the Gordon Subgroup.

Squirrel Creek Formation

Conformably overlying the Upper Sandstone Member of the Reeds Conglomerate, and underlying the limestone sequence of the Vale of Rasselas, is a sequence of about 600 metres of fossiliferous marine sandstone, siltstone and impure limestone designated the Squirrel Creek Formation. A lower sandstone member, a siltstone-limestone member and an upper sandstone member are distinguished. The sequence can be correlated with the Florentine Valley Formation of the Tim Shea area (Corbett and Banks 1974), but is separated from that section by an area of poor exposure and superficial cover around the southern Vale of Rasselas. Further mapping may establish precise equivalence of

the two formations, in which case the new name can be dropped in favour of Florentine Valley Formation. The sequence dips east at about 55°, and is best exposed in Squirrel Creek and south thereof.

The lower sandstone member is about 150 metres thick, and is best exposed on the lowermost dip slopes of the Denison Range between Hanging Lake and just north of Squirrel Creek. It consists typically of flat-bedded and flaggy white siliceous sandstone, with lesser cross-bedded coarse sandstone, micaceous siltstone and glauconitic sandstone. Worm burrows and casts, and bioturbated zones, are common. Gastropods occur in a few beds, and include a form close to *Raphistoma* sp., suggesting an Early Ordovician age (M.R. Banks, *pers. comm.*).

The siltstone-limestone member is about 150 metres thick, and forms a narrow valley at the foot of the range. In Squirrel Creek it consists of interbedded grey to yellow calcareous siltstone, fine sandstone, and impure nodular limestone. It contains an abundant fauna of trilobites (including *Asaphopsis juneensis*), brachiopods and gastropods. The fauna is similar to that of the Florentine Valley Formation at The Gap (Corbett and Banks 1974) and is Early Ordovician in age.

The upper sandstone member is about 300 metres thick, and forms a low ridge (Timbs Ridge) just east of the range. In Squirrel Creek it consists of grey, green and buff-coloured quartzose and micaceous sandstone with interbedded siltstone and glauconite bands. It contains a sparse fauna of brachiopods, trilobites and gastropods.

GORDON SUBGROUP CORRELATE

Limestone correlated with the Gordon Subgroup of Corbett and Banks (this volume) is poorly exposed in the Vale of Rasselas east of Timbs Ridge. The lower part of the sequence was examined in Squirrel Creek, where bars of impure stylolitic and nodular limestone are intermittently exposed over a stratigraphic interval of about 650 metres (assuming 50° dip). Above this is a unit of white-weathering siliceous coarse sandstone, about 60 metres thick, which forms a narrow strike ridge in the central part of the valley. The sandstone is cross-bedded in places, and contains traces of marine fossils and worm burrows. The limestone sequence above this was not examined.

A ridge of similar coarse siliceous sandstone occurs within the limestone sequence in the valley north of Battlement Hills (Corbett 1970).

ACKNOWLEDGEMENTS

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REVISED TERMINOLOGY OF THE LATE CAMBRIAN-ORDOVICIAN SEQUENCE OF THE FLORENTINE-DENISON RANGE AREA, AND THE SIGNIFICANCE OF THE "JUNEE GROUP"

by K.D. Corbett, Department of Mines, Hobart, and

Maxwell R. Banks, University of Tasmania.

(with one text-figure)

ABSTRACT

The area of Lewis's original "Junee Series" is unsuitable as a basis for definitive stratigraphy and correlation, even with units in adjacent areas. A review of the various usages and concepts associated with the "Junee Group" indicates considerable diversity in meaning and application of the term, and suggests that the sequences are better considered in terms of a lower clastic unit and an upper limestone unit rather than as a single group. Accordingly, the Late Cambrian-Ordovician sequence in the Florentine Synclinorium is defined in terms of the Denison Subgroup, comprising four formations between the basal unconformity on the Denison Range and the base of the limestone, and the Gordon Subgroup, comprising three limestone formations and the Westfield Beds. These two Subgroups together approximate to the "Junee Group".

INTRODUCTION

The contribution by Brown *et al.* (this volume), on the basal beds of the Junee Group, raises many questions as to the terminology applied to the Early Palaeozoic sequences in Tasmania. A previous definition proposed by us (Corbett and Banks 1974) for the Junee Group is criticized on the grounds that, by including the Reeds Conglomerate (from the Denison Range) as well as the Tim Shea Sandstone in the definition, we have introduced a questionable correlation and have contravened the Australian Code of Stratigraphic Nomenclature with respect to the location of type sections and the validation of terms by later workers.

We accept that the correlation is not provable and that any possible ambiguity should be removed. Our definition was influenced by our firm view that Lewis's (1940) area of the "Junee Series" is unsuitable as a basis for definitive stratigraphy and for regional correlations, and that to define the group from strictly within that area would make for an impracticable term. That view we still hold.

Because it was originally poorly defined, the "Junee Group" has been used in different ways by different authors, depending on their concept of its regional significance. We review these usages and concepts in the light of new information and the arguments of Brown *et al.*, and conclude that the usefulness of the "Junee Group" is limited in either a generalized form or as designated by Lewis in the Junee area. A terminology based on a lower clastic unit and an upper limestone unit seems more useful, and our earlier terminology for the Florentine-Denison area is revised accordingly.

USAGE OF THE "JUNEE GROUP"

Although Lewis (1940) originally defined the "Junee Series" from the Tyenna Valley area (including The Needles, Tim Shea, Wherrett's Lookout, and the Junee - now Maydena - area) he did not specify any type sections or give formation names.

Hills and Carey (1949) borrowed the term for their "Junee Group", comprising formations from widely-separated areas of Tasmania, and this generalized usage was

continued by Banks (1962), who defined the group in terms of the Jukes Conglomerate, Owen Conglomerate, Caroline Creek Sandstone, Florentine Valley Mudstone, Gordon Limestone and "Fenestella Shale". This generalized term has been used in discussions of the Tasmanian sequence for many years, and is still used by some people.

The present authors (1974), in redefining the group in the Florentine Synclinorium, attempted to amalgamate the generalized "Junee Group" usage with the ill-defined "Junee Series" by using only formations which could be defined in the general Tim Shea - Florentine - Denison Range area. We did not feel obliged to restrict the definition entirely to within the area of Lewis's "Junee Series" because: (a) there was a long historical precedent for using the term outside that area; (b) the area selected was adjacent to and physically continuous with that of Lewis; (c) there were serious problems due to the lack of exposure of Lewis's area, as discussed below; and (d) there were well-established precedents for not using the first-designated area to define an important group if the area was unsuitable or impracticable. For example, the Dundas Group was first designated by Waller (1905) as the sequence on the NE Dundas Tram but was redefined by Elliston (1954) on the Dundas Rivulet; and the Eldon Group of Gould (1866) from the inaccessible Eldon River area was redefined by Gill and Banks (1950) near Zeehan. Both these terms are accepted and in general use.

Williams (in Jennings *et al.* 1967) referred the term "Junee Group" to the Maydena - Tim Shea area, and the Geological Survey of Tasmania in recent years has referred to sequences elsewhere as "Junee Group correlates" without specifying the composition or origin of the "Junee Group" referred to (e.g. Williams and Turner 1974). It is unfortunate that the Survey's assessment of the validity or otherwise of the "Junee Group" usage of Banks (1962) and others, was not made clear at an earlier date, since by inference Brown *et al.* (this volume) would regard this usage as invalid.

CONCEPTS ASSOCIATED WITH THE "JUNEE GROUP"

Several concepts have been associated with the "Junee Group" and have influenced the application of the term over the years, but need re-evaluation in the light of new information. The idea of the group as a single major cycle of sedimentation, from non-marine conglomerate to limestone, was put forward by Carey (1947) and has been fairly generally applied since then (e.g. Banks 1962). Together with this has been the idea that the group encompassed most or all of the Ordovician Period, since the lowermost fossils were of Early Ordovician age and the uppermost probably Late Ordovician. Thus "Junee Group" and "Ordovician System" have been used almost synonomously (e.g. Banks 1962; Williams and Turner 1974). The recent discovery by one of us of middle Late Cambrian fossils in a marine facies of the lower part of the Owen Conglomerate correlate on the Tyndall Range (Corbett in press) indicates that the "Junee Group" (sensu Banks) can contain an earlier marine cycle and that the lower part may include much of the Late Cambrian Series. This is also demonstrated by the Denison Range sequence (Corbett this volume).

The concept that the "Junee Group" marks the beginning of deposition of siliceous clastics, following the greywacke sedimentation typical of the Cambrian, has been expressed more recently (e.g. Williams, Solomon and Green 1975). However, in some areas at least, considerable amounts of siliceous conglomerate and sandstone were deposited in Middle or Late Cambrian sequences which must be regarded as pre-"Junee Group", e.g. in the Strahan area (Baillie *et al.* in press), and in the Trial Ridge area (A.V. Brown and N.J. Turner, *pers. comm.*; Corbett this volume).

Because of the varying usages and concepts, the meaning of the "Junee Group" in regional correlations and discussions has become confused, and its value as a widely usable term is doubtful. Another means of considering the Late Cambrian-Ordovician sequences of Tasmania has emerged in recent years. This involves splitting the sequence into a lower clastic unit of mainly conglomerate and sandstone, and an upper limestone

unit. This two-fold division has been used on recent Geological Survey one mile maps (e.g. Barton *et al.* 1966; Barton *et al.* 1969), with the clastic sequence being generally referred to as "correlates of Owen Conglomerate", and the limestone sequence as "correlate of Gordon Limestone". The same subdivision is being used on the recent 1:250,000 scale compilations (e.g. Williams and Turner 1974), and on the 1:500,000 geological map of Tasmania (in preparation).

We believe that this two-fold subdivision reflects a fundamental character of the sequence, and is therefore likely to be of more future benefit than a single group term. The terminology of the Denison-Florentine sequence has accordingly been designated in terms of two subgroups, one for the lower clastic sequence, which is best developed in the Denison Range area, and one for the limestone sequence of the Florentine Valley. These two subgroups approximate to the old "Junee Group", but are designed so that they can be used independently, with the aim of eventually raising them to group status if the usage of "Junee Group" becomes impracticable.

THE LOWER CLASTIC SEQUENCE (DENISON SUBGROUP)

On the Denison Range the clastic sequence is some 3390 metres thick (fig. 1) and comprises four formations (Singing Creek Formation; Great Dome Sandstone; Reeds Conglomerate; Squirrel Creek Formation) defined as the Denison Subgroup (Corbett this volume). The Squirrel Creek Formation is a correlate of the Florentine Valley Formation and is of Early Ordovician age. The basal Singing Creek Formation comprises siltstone, quartzwacke and siliceous conglomerate, and contains middle Late Cambrian (Franconian) fossils. It rests with angular unconformity on Middle Cambrian beds, and this unconformity can be traced south through the Ragged Range to Frodshams Pass (Corbett 1970; Corbett and Banks 1974). East of this, the area of the unconformity is covered by dense forest, but the siliceous sandstone-conglomerate sequence transgresses various Precambrian and Cambrian rock types and structural features, and the unconformity is again exposed at Tim Shea (fig. 1).

The clastic sequence at Tim Shea, which is in the area mapped by Lewis as "Junee Series", is only some 750 m thick (fig. 1) and comprises the poorly fossiliferous Tim Shea Sandstone and the fossiliferous Florentine Valley Formation (Corbett and Banks 1974). The basal unconformity is on Precambrian dolomite on the south flank of the peak, although Lewis did not recognise it here (see Carey and Banks 1954). The Tim Shea Sandstone probably corresponds to the lower unit of Lewis's "Junee Series", the "quartzites with conglomerates and breccias interbedded", and the Florentine Valley Formation to Lewis's second unit, the "yellow mudstones with trilobites and other fossils of lower ordovician age".

The area first mentioned by Lewis (1940) as "Junee Series" is that around Junee (now Maydena) and Sunshine Spur, the latter some 8 km southeast of Tim Shea. Here he recognised a lower quartzite unit overlain by yellow fossiliferous mudstone followed by limestone. This relationship was also mapped by Everard and Hughes (in Hughes 1957, fig. 47) and has since been confirmed by R.K. Whyte (*pers. comm.*). Dense vegetation precludes tracing of the lower units between here and Tim Shea, although Lewis's correlation to Tim Shea is probably correct. The basal part of the sequence is exposed only at Sunshine Spur, where poor exposures suggest unconformity between basal conglomeratic beds and an underlying sandstone-siltstone sequence of unknown age.

The Denison Range section has many advantages over those at Tim Shea and Sunshine Spur as the basis for definition of the lower clastic sequence, as for example:
(i) The Tim Shea Sandstone is atypical in that it lacks the coarse conglomerates which occur along the whole western part of the synclinorium. These conglomerates reach their maximum development (1560 m) on the Denison Range (Corbett and Banks 1974).
(ii) Use of the Tim Shea or Sunshine Spur sections would leave doubt as to whether the Singing Creek Formation, which does not appear to be represented in the latter areas, should or should not be regarded as part of the group or subgroup.

Similarly it would be arguable if the Great Dome Sandstone (fig. 1) should be included, as evidenced by the discussion of Brown *et al.* (this volume).

(iii) Since the Tim Shea sequence sets directly on Precambrian rocks, the relationship to Cambrian sequences is difficult to specify. On the Denison Range, however, the unconformity is on fossiliferous Cambrian beds, and its significance and time range are more readily apparent.

(iv) There is no control on the age of the base at Tim Shea or Sunshine Spur, whereas on the Denison Range the beds above the unconformity contain a well-preserved and dated fauna (Corbett this volume).

(v) The Sunshine Spur section is poorly exposed.

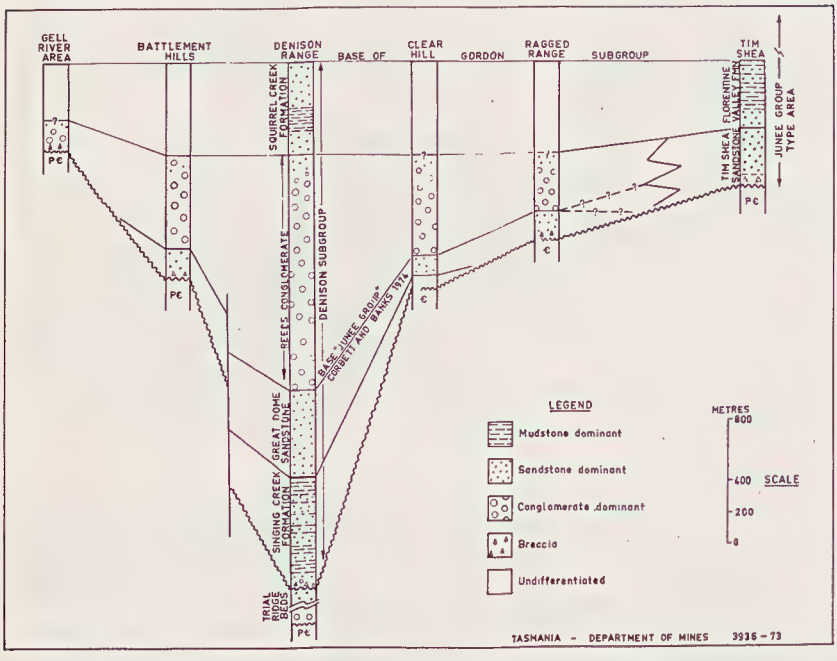

FIG. 1. - Correlation chart for lower clastic sequence in Florentine Synclinorium; horizontal distances not to scale; thicknesses approximate.

It was for these reasons that we earlier decided that a Junee Group defined either at Tim Shea or in the Junee area would be of little value, and accordingly defined an alternative base for the group in the Denison Range section (Corbett and Banks 1974). We selected the base of the Reeds Conglomerate for what we then considered were several good reasons: (a) we wished to exclude the fossiliferous Late Cambrian beds since these did not appear to be present at Tim Shea and their inclusion would create problems of correlation to western Tasmania; (b) the use of a conglomerate as the base agreed with previous usage (e.g. Banks 1962); (c) we were influenced by the cycle of sedimentation concept; and (d) we regarded the Reeds and Tim Shea Formations as equivalents (fig. 1), although realizing that this was probably not provable.

Several arguments indicate that the Junee Group should not be defined in this way. Firstly, as pointed out by Brown *et al.* (this volume), there is a questionable correlation involved in the definition which makes it confusing. Secondly, there is the question of extending the type area beyond that of Lewis's original "Junee Series", and while we believe there is good precedent for doing this, there is little point if users of the term object. Thirdly, there is recent geological evidence to indicate that the base of the Reeds Conglomerate is not the most logical place for the base of the group. In particular, the discovery of a fossiliferous Late Cambrian marine facies

in the lower part of the Owen Conglomerate indicates that the Junee Group (sensu Banks 1962) can include equivalents of the Singing Creek Formation.

The unconformity which occurs below the Singing Creek Formation, and which almost certainly corresponds to that in Lewis's type area, is the logical place for the base of the clastic sequence, just as the Denison Range is the logical place to define the sequence. The Denison Subgroup has been established accordingly, and while it is not defined as being part of the Junee Group (sensu stricto) it may be regarded as approximating the pre-limestone part of that group.

THE LIMESTONE SEQUENCE (GORDON SUBGROUP)

Conformably overlying the lower clastic sequence is a thick limestone succession with some minor siltstone-sandstone units. The limestone is poorly exposed in the Denison Range area because of the cover of superficial gravels, but is well exposed in the Florentine Valley. We used sections in the latter area to define our Gordon Limestone Subgroup (comprising three formations) and an overlying passage unit of siltstone and sandstone called the Westfield Beds.

The limestone sequence of the Florentine Valley is partly the same unit as Lewis's "blue Junee limestone" of the "Junee Series", but is outside his area. The basal limestone formation can be traced (Whyte, *pers. comm.*) from Junee into the Florentine Valley where it has been named Karmberg Limestone (Corbett and Banks 1974). Where mapped by Lewis, the limestone sequence is truncated unconformably by the Permo-Carboniferous beds, and to define the unit here would leave doubt as to the constitution of the upper part of the sequence and the relationship with the Siluro-Devonian sequence (Eldon Group correlates). This relationship is well shown in the Florentine Valley, however, and the exposures of limestone there are much better.

It is clearly preferable to use the Florentine Valley sections to define the limestone sequence, but there could be argument as to whether the sequence here corresponds precisely to that of the "Junee Series". We therefore do not define the Junee Group as containing this sequence, but regard it as approximating the "Junee limestone" of Lewis.

For convenience of correlation, we hereby slightly amend our earlier terminology in order that all the units below the Eldon Group correlates, and above the lower clastic sequence, be included in a single subgroup. We define the *Gordon Subgroup* as including the Westfield Beds at the top as well as the three limestone formations, i.e. the Karmberg Limestone at the base, the Cashions Creek Limestone, and the Benjamin Limestone. All units have previously been defined by Corbett and Banks (1974). The base of the Subgroup can be traced, as far as outcrop allows, from the Junee area to the valley of the Gordon River east of the Dension Range, where the Gordon Subgroup rests conformably on the Denison Subgroup.

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OBSERVATIONS ON SOME TASMANIAN FISHES: PART XXI

by E.O.G. Scott, Launceston

(with four tables and two text-figures)

ABSTRACT

Two new species are described and figured: *Muraenichthys lingowenah* (Echelidae), *Arnoglossus armstrongi* (Bothidae).

Four species are added to the Tasmanian list: *Kyphosus sydneyanus* (Günther) (Kyphosidae), *Kyphosus gibsoni* Ogilby, *Zebrias fasciata* Macleay (first Tasmanian representative of Soleidae), *Navodon degeni* (Regan) (Aluteridae); accounts are given of material on which the records are based.

General observations are made on: *Muraenichthys breviceps* Günther (Echelidae: correlation of body ratios with total length), *Muraenichthys tasmaniensis* McCulloch (new material, comparison with *M. t. smithi* Whitley), *Mitotichthys tuckeri* (Scott) (Syngnathidae: new material), *Zeus faber* Linné (Zeidae: young example), *Cyttus australis* (Günther) (Zeidae: specific determination in terms of some commonly employed criteria), *Enoplosus armatus* (White) (Enoplosidae: sample of 29 juveniles, table of dimensions, relative growth, coloration), *Katsuwonus pelamis* Linné (Katsuwonidae: specimen from Tamar river, disposition of finlets), *Lophonectes gallus* Gunther (Bothidae: comparison with published accounts), *Brachionichthys hirsutus* (Lacépède) (Brachionichthyidae: northern Tasmanian material).

INTRODUCTION

This paper follows the general plan of others in the series. Linear measurements, except where otherwise stated, are given in millimetres, the name of the unit commonly being omitted. The symbols *Ls, Lt, TLs, TLt* denote standard length, total length, millesimals of standard length, millesimals of total length, respectively. Standard deviation is calculated with n degrees of freedom; derived statistics being computed from the value thus obtained. Registration numbers, unless otherwise noted, are those of the Queen Victoria Museum, Launceston. Certain other conventions are noted in earlier contributions.

Some routine measurements in several species of the lengths of spines and rays have revealed length-position patterns. These patterns and procedures in their investigation have been discussed in Part XIX (Scott 1974a, p. 248); where it is noted that the lengths (arithmetic or, usually, logarithmic) in a group of radial elements are frequently found to be a linear function of the serial numbers (arithmetic, or, usually, logarithmic) of the elements. Serial numbers counted from the most anterior element of the set or subset in the dorsal and anal, from the uppermost ray in the pectoral and caudal, from the ray farthest from the spine in the ventral are denoted by N, numbers counted in reverse by N'.

Family ECHELIDAE

References to Echelidae have been made in these observations in Parts II(1936), VI (1953), VIII(1957), X(1961), XI(1963), XIX(1974). To the two species accredited to the State in the Check-list (McCulloch 1929) — *Muraenichthys breviceps* Gunther, 1876, *M. tasmaniensis* McCulloch, 1911 (both with Tasmania as type locality), — *M. australis* Macleay, 1881 (type locality, New South Wales) was added in Part III (1936, p. 114) and *M. ogilbyi* Fowler, 1908 (type locality, Victoria) in Part XIX (1974).

A new species of *Muraenichthys* is here described. In the 1974 key to species recorded from Tasmania the new form would enter couplet 3; but is distinguishable immediately from the two species there entered by its low value for Schmidt's index (about 2; contrast about 18-22), and, more comprehensively, by certain other characters set out in table 1 below. Some observations are made on the correlation of certain body ratios with *Lt* in *M. breviceps*, and some dimensions of a specimen of *M. tasmaniensis* and of two specimens of *M. australis* are noted; some remarks are made regarding the status of the Western Australian *M. tasmaniensis smithi* (Whitley,1944).

Genus *MURAENICHTHYS* Bleeker, 1865

Muraenichthys Bleeker, 1865, *Nat. Tijdschr. Dierk.*, 2, p. 117. Orthotype, *M. gymnopterus* Bleeker.

Muraenichthys Tingowenah sp. nov.
(fig. 1)

Diagnosis. Attenuate; dorsal originating in advance of vent by about one-fourth head; head about five times in trunk; teeth (upper jaw) chiefly uniserial, briefly biserial anteriorly; heavily punctulated, darker above, no gross markings.

Principal dimensions. Length to base of caudal rays, *Ls*, 183.3 mm, total length, *Lt*, 183.6 mm. Dimensions that follow are given as *Tlt* (absolute measurement, mm, in parentheses). Length to dorsal origin 430 (79.0), to vent (middle) 446 (82.0), to anal origin 452 (83.0). Head 70.3 (12.9), snout 10.9 (2.0), eye 5.4 (1.0), interorbital 6.0 (1.1), mouth cleft to end of rictal groove 25.1 (4.6), to angle of free gape 18.5 (3.4). Maximum depth of head 15.3 (2.8), of body 16.1 (2.95); depth at vent 13.6 (2.5). Maximum width of head 13.6 (2.5), of body 16.9 (3.1); width at vent 16.3 (3.0).

General features. Body long, slender, depth 62.2 in *Lt*, subcylindrical anteriorly, becoming progressively compressed caudad, notably in the posterior one-third. Branchial sac extending somewhat beyond the general profile ventrally, scarcely so laterally, its depth about 1.1 its width, subequal to combined lengths of eye and snout. Gill opening small, subequal to pupil; infero-lateral, its upper angle below lateral line (here about equidistant from dorsal and ventral profiles) by its own oblique length, or a trifle more; its lower angle distant from that of its fellow by rather more than twice slit length. Head small, 5.4 in trunk, 14.2 in *Lt*; subcylindrical. Snout rounded dorsally, moderately acute, its length twice eye, 5.2 in head. Lower jaw imperfect anteriorly, but shorter than upper when perfect; with mouth closed, its tip evidently fitting up into palate just behind upper lip. Anterior nostril in upper lip, briefly tubular, overhanging front part of lower jaw. Posterior nostril a slit in upper lip about at level of front of eye, overhung by a small downwardly directed flap. Eye moderate, a trifle longer horizontally than vertically, 2.5 in snout, 12.9 in head; closer to mouth cleft than to dorsal profile, its distance from the former about one-fourth its own vertical diameter; margin somewhat indeterminate, bounded below and behind by a low fleshy ridge. Interorbital 1.1 eye, 11.7 in head, gently convex both antero-posteriorly and transversely. Normal free gape about to posterior border of eye, rictal groove to behind eye by about eye diameter. Teeth in upper jaw of moderate length, stout, conical, some a little recurved; uniserial, briefly and irregularly biserial anteriorly (probably similarly disposed in lower jaw; damaged); a small irregular patch on vomer; on the palate in two well-developed linear series, approximate anteriorly, diverging posteriorly. Head with a number of pores. Lateral line originating near front of branchial basket, above it slightly convex; immediately behind basket about equidistant from dorsal and ventral profiles; on part of trunk rising to be decidedly nearer dorsal than ventral profile; in rest of its course caudad about equidistant from the profiles; represented by a conspicuous, narrow, grossly continuous ridge; a ridge similar in general appearance, joining anterior ends of the two lateral lines in a slightly forwardly convex arc across occiput.

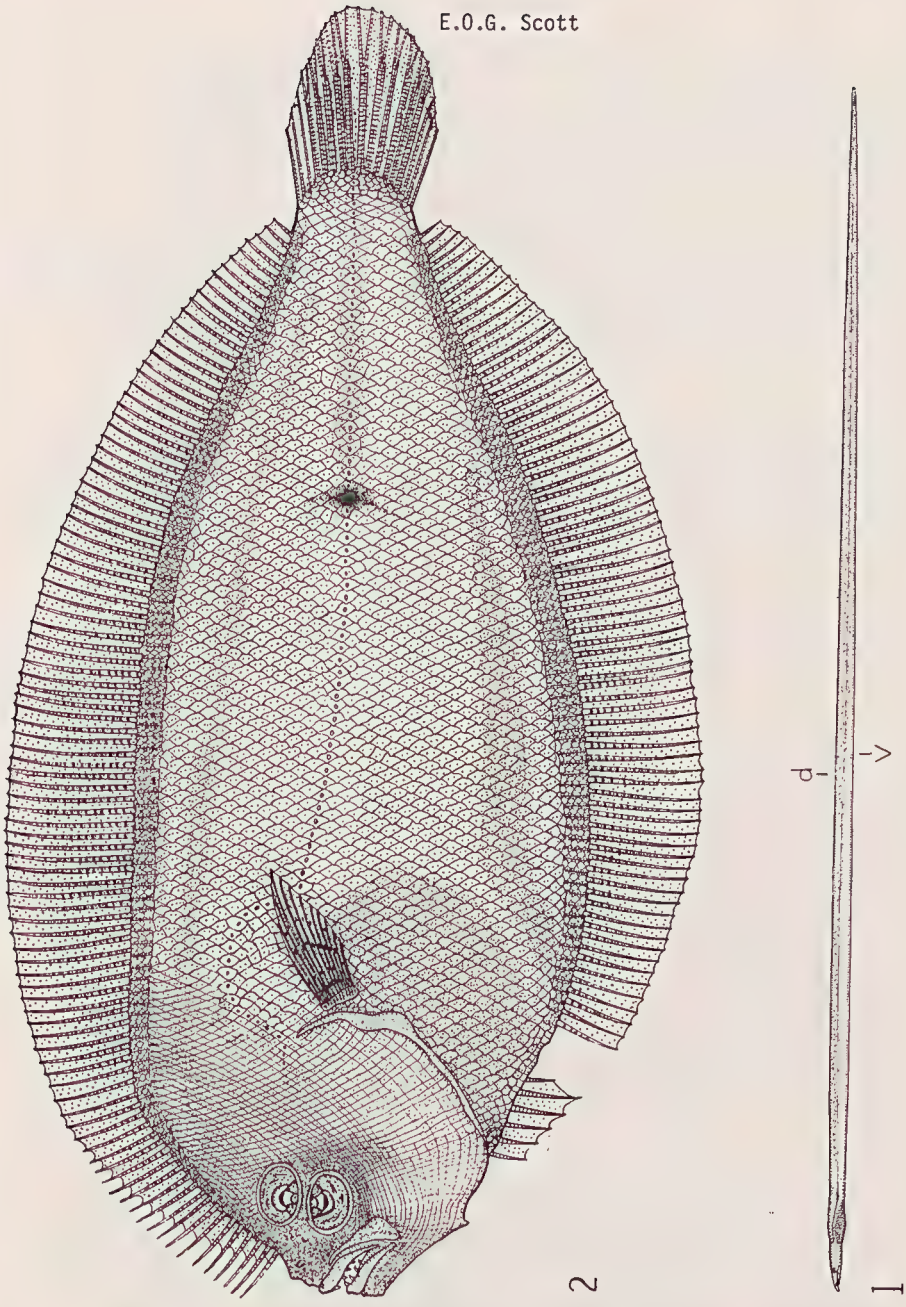

FIG. 1. - *Muraenichthys lingowenah* sp. nov.; holotype; total length 183.6 mm; off Prime Seal Island, Furneaux Group, Bass Strait. Queen Victoria Museum Reg. No. 1974/5/58.

FIG. 2. - *Arnoglossus armstrongi* sp. nov.; holotype; standard length 168.5 mm; Bridport, northern Tasmania. Queen Victoria Museum Reg. No. 1974/5/168.

Fins inconspicuous, almost completely lapsed into grooves; evidently low. Dorsal originating in advance of vent by distance equal to combined snout and eye; at 0.96 of length of combined head and trunk, or 0.43 of total length. Schmidt's index, S = 1.63 ($S = \frac{Lv - Ld}{Lt}$, where Lv = length to vent, Ld = length to dorsal origin, Lt = total length). Dorsal and anal evenly confluent with a minute caudal fin with imperfectly developed rays and barely recognizable as a distinct entity.

Coloration. As preserved in formalin, dorsal and lateral surfaces of trunk and tail ranging from yellowish, with some tinge of greenish, anteriorly to pale orange or amber, still with some occasional hint of green, posteriorly; intense peppering with spots and splashes of reddish brown, confined in anterior portion of trunk to dorsal surface and lateral surface down to level of lateral line, extending progressively lower down caudad, reaching ventral profile at about middle of total length. Whole ventral surface of trunk and tail amber or brownish orange.

Whole lateral and dorsal aspects of upper part of snout and intact (posterior) portion of lower jaw to level of posterior orbital border yellowish, with some tinge of greenish, punctulated abundantly, except for a small patch in front of eye and on much of lower jaw, with reddish brown; postorbital portion of head pale yellowish, punctulated and minutely flecked, somewhat less densely than anterior portion of head, with reddish brown; ventral surface mostly yellowish, immaculate, but with some dark punctulation on inferior surface of mandible.

Material. Described and figured (fig. 1) from the unique holotype, 183.6 mm in total length, 183.3 mm to base of degenerate caudal, collected by Mr P. Armstrong off Prime Seal Island, Furneaux Group, Bass Strait, 24 August 1973; Q.V.M. Reg. No. 1974/5/58.

The second binomen, *lingowenah*, is one of two words for eel recorded in Milligan's vocabulary of the extinct Tasmanian aborigines (Ling Roth 1899), this being employed by tribes about Mount Royal, Bruny Island, Recherche Bay and the south of the island.

Affinities. Of the four muraenichthids hitherto recorded from Tasmania, only two, *Muraenichthys breviceps* Gunther, 1876, and *M. ogilbyi* Fowler, 1908, have the dorsal originating in advance of the anal. In both these forms the forward extension of the dorsal on to the trunk is considerable, being equal to, or greater than, length from tip of snout to fin origin, and being twice, or more, length of head: in the present species the corresponding values are less than one-twentieth and less than one-fourth. This approximation of dorsal origin to vent in *M. lingowenah* is reflected in the low value for Schmidt's index, 1.63, values for the other species exceeding 15. Two other noteworthy features exhibited by the new species are the extreme attenuation, greater than that hitherto precisely recorded for any Australian form (maximum depth upwards of 60 in *Lt*, *cf.* about 25-45) — Macleay noted of *M. australis* "Body very slender, its depth being about one-sixtieth of its length" (data given by McCulloch for the type specimen works out at depth about 45 in *Lt*)— and the small head (more than 5 times in trunk, *cf.* about 3-4).

Of the members of the genus recognized in the Handbook (Munro 1957a, p. 46) two other, non-Tasmanian species have dorsal origin on trunk, namely, *M. devisi* Fowler, 1908 (Victoria) and *M. godeffroyi* Regan, 1909 (Queensland). Difference between *M. lingowenah* and the former include dorsal originating at 0.96 of distance between gill opening and vent (*M. devisi* 0.25), head 14.2 (10) in *Lt*, combined head and trunk 1.24 (1.5) in tail, eye 2.0 (3.25) in snout; while Regan's species, for which few comparative data are available, clearly has a much more anteriorly inserted dorsal, and a decidedly larger head (3.2 in trunk, *cf.* 5.36 here).

Some comparative quantitative data on the three Tasmanian long-finned species are set out in table 1. Entries for *M. ogilbyi* are provided by the description of the type

TABLE 1

Muraenichthys lingowenah sp. nov. Comparison of some proportions with those of *M. breviceps* Günther, 1876 (8 Tasmanian examples) and *M. ogilbyi* Fowler, 1908 (holotype, 1 Tasmanian example). For details of Tasmanian material see text.

Feature	Species A	B (i)	B (ii)	C (i)	C (ii)
Total length, mm	183.6	3.46	239	234.8 - 583.0	412.2 ± 36.0
Schmidt's index, *S*	1.6	20.7	18.7	19.1 - 21.9	20.6 ± 2.95
Maximum depth in head	4.37	2.25	2.75	2.52 - 4.10	3.23 ± 0.17
Maximum depth in total length	62.2	26.4	29.9	29.3 - 45.2	37.6 ± 1.73
Head in trunk	5.36	3.40	2.95	3.01 - 4.04	3.40 ± 0.11
Head in total length	14.2	11.8	10.9	11.0 - 13.3	11.8 ± 0.25
Head in dorsal-bearing trunk	0.23	2.43	2.02	2.17 - 2.90	2.41 ± 0.081
Precaudal length in tail	1.24	1.66	1.75	1.63 - 1.80	1.69 ± 0.020
Predorsal trunk in total trunk	1.05	2.87	3.17	3.10 - 3.60	3.45 ± 0.052
Predorsal length in remainder of length	1.32	4.94	4.62	4.59 - 5.20	4.94 ± 0.059

A. *M. lingowenah*

B. *M. ogilbyi*: (i) holotype; (ii) Tasmanian example.

C. *M. breviceps*: (i) range; (ii) mean.

specimen from Victoria, *Lt ca* 346, and, more extensively, by a Tasmanian example (the first reported for the State), *Lt* 239, Green's Beach, January (R.H. Green), noted in Part XIX (1974, p. 161): those for *M. breviceps* by 8 individuals, as follows (*a*) *Lt* 583 Tamar river at Blackwall, 5 July 1935 (Lyall), (*b*) *Lt* 491, Stanley, received 28 February 1938 (B.C. Mollison), (*c*) - (*f*) *Lt* 393.3, 370.5, 313.5, 234.8, off Maatsuyker Island, about November 1953 (J.R. Cowper), (*g*) *Lt* 439, Low Head, December 1960 (Miss A. Seager), (*h*) *Lt* 472.5, Derwent river at Long Point, Sandy Bay, 3 February 1961 (D.H. Hobbs). Individuals (*a*) - (*f*) have been noted in Part VIII (1957, 150), (*g*), (*h*) in Part XI (1963, 14), where accounts of them include some additional information on their sources of origin and the circumstances of their collection.

Muraenichthys breviceps Günther, 1876

Muraenichthys breviceps Günther, 1876, *Ann. Mag. Nat. Hist.*, (ser. 4), 17, p. 401.
Type locality: Tasmania (M. Allport).

Correlation of certain body ratios with *Lt*. It is interesting to note that, even with the small sample of eight individuals, of the nine body ratios for this species entered in table 1, no fewer than six exhibit systematic variation in magnitude with length of fish. As a measure of the correlation of each of these six ratios with *Lt*, there are given below, first, r (with sign), secondly, z (in parentheses), thirdly t, significance at levels of $P \leq 0.01$, ≤ 0.05, ≤ 0.1 being indicated by the addition to the t of two asterisks, one asterisk, no asterisk, respectively.

Schmidt's index +0.918 (1.578), 5.677 **; maximum depth in head –0.704 (0.876), 2.429; head in trunk +0.899 (1.469), 5.037 **; head in total length +0.778 (1.040), 3.103*; head in dorsal-bearing trunk +0.827 (1.176), 3.604*; precaudal length in tail –0.870 (1.332), 4.316**.

Symmetry of samples. As measured by the number of individuals occurring within the range $\bar{x} \pm s$, all the samples of ratios in table 1, together with *Lt*, are tolerably symmetrical. The number of entries within $\bar{x} \pm s$ for maximum depth in head and for head in trunk is 5; for all other ratios there listed, and for *Lt*, 6 (*cf.*, for infinite population, $\bar{x} \pm \sigma = 5.5$).

Muraenichthys tasmaniensis McCulloch, 1911

Muraenichthys tasmaniensis McCulloch, 1911, *Zool. Res. Endeavour*, 1, p. 19, fig. 5.
Type locality, Oyster Bay, Tasmania.

Additional material. Tasmanian material on which data are available are the holotype, *Lt* 170, and two examples, *Lt* 198, *Lt* 265, reported upon earlier in these Observations (1961, 1965). Some data are here presented on a larger individual, *Lt* 302, collected by Mr P. Armstrong off Prime Seal Island, Furneaux Group, Bass Strait, 24 August 1973; Q.V.M. Reg. No. 1974/5/57.

Dimensions. Values are given as *Tlt*, with absolute dimensions, mm, in parentheses. To provide some comparative data in connexion with remarks below on the status of the Western Australian *M. tasmaniensis smithi* (Whitley, 1944) *Tlt* values for the type, *Lt* 275, and paratype, *Lt ca* 350, of that species are here given in square brackets. Length to vent 440 (133) [447, 440], to dorsal origin 488 (147.5) [491, 514], to anal origin 445 (134.5) [–, –]. Head 73 (22) [84, 83]. Snout 11 (3.3) [16, 14]. Eye 3.7 (1.1) [7.3, 6.4]. Interorbital 6.3 (1.9) [9.1, 10]. Mouth cleft to angle of free gape 17 (5.0), to end of rictal groove 23 (7.0) [as measured, 18, 17]. Depth at back of eye 8.3 (2.5), middle of branchial sac 21 (6.2), gill opening 18 (6.2), vent 15 (4.5); maximum depth 21 [20, 23]: widths at same points 13 (3.9), 18 (5.4), 16 (4.8); maximum width 18 (5.4).

Comparative proportions. Some eight proportions of the holotype were given by McCulloch (1911, 19). His values are here followed by those for our three examples, all specimens in ascending order of magnitude of *Lt*; followed in square brackets by those for the type and paratype of *M. t. smithi*. Depth in head 3.3, 3.5, 2.9, 3.7 [4.2, 3.6]. Head in *Lt* 12.8, 12.3, 13.3, 13.7 [11.9, 12.1], in trunk 4.3, 4.1, 4.7, 5.0 [4.3, 4.3]. Eye in snout 3.2, 3.8, 3.4, 3.0 [2.3, 2.4]. Snout in head 4.8, 5.4, 5.8, 6.7 [5.1, 5.8]. Mouth cleft in head to end of rictal groove 2.7, 3.0, 3.0, 3.1, to angle of free gape —, —, 4.4 [4.6, 4.8]. Length to vent in tail 1.4, 1.42, 1.28, 1.27 [1.23, 1.27]. Distance of dorsal origin from vent relative to head length 'equal to head', 0.8 head, 0.9, 0.7 [0.9, 0.9].

Schmidt's index. No data for holotype, 6.60, 2.64, 4.80 [4.36, *ca* 7.43].

Status of *M. t. smithi*. Data set out above suggest some remarks on the status of *M. t. smithi*, which agrees with McCulloch's fish in having teeth in the jaws uniserial, but of which it is noted (Whitley 1944, p. 263) 'the snout is relatively shorter than in the Tasmanian type of *Muraenichthys tasmaniensis* McCulloch ... and the gape of the mouth more extensive.' With regard to the first point, reference to the comparative proportions set out above shows that while the snout in Western Australian specimens is relatively shorter (compared with head length) than in the type (5.1, 5.8 in head; *cf.* 4.8) the same is true in all our three examples, one of which is as short as, one shorter than, the shorter of the two examples of *M. t. smithi*. McCulloch did not give any actual measurements (apart from *Lt*): by double calculation, *Tlt* value for snout of holotype comes out at 16 (*cf.* Whitley's 16, 14). As regards mouth cleft, the above figures show that this is relatively less, not more, extensive in both Whitley's specimens than in McCulloch's type. The difference is not inconsiderable: however, it is to be noted that this dimension is subject to several possible interpretations, as the measurement can legitimately be taken, according to the convention adopted, either from tip of upper or of lower jaw to oral membrane connecting hinder parts of the jaws, or farther back to what may be regarded as normal angle of jaws, or farther back still to end of rictal groove. With cleft expressed in *Tlt* there is no great difference between the two Western Australian specimens (18, 17) and the present individual (23); however, values for the other Tasmanian examples, 27, 25, 29 (holotype computed), are noticeably larger. Comparison of the overall data of the four Tasmanian and the two Western Australian specimens (the latter themselves presenting some quantitative difference) thus suggests a distinct possibility that proportions recorded for *M. tasmaniensis smithi* may fall within the range of individual variation of *M. tasmaniensis*.

Muraenichthys australis Macleay, 1881

Muraenichthys australis Macleay, 1881, *Proc. Linn. Soc. N.S.W.*, 6(2), p. 272. Type locality, New South Wales.

Additional material. Quantitative data are available for only one Tasmanian example, *Lt* 272, noted in Part III (1936, 114), constituting the first record for the State. Observations are here made on two other local examples, (*a*) *Lt* 318, Eaglehawk Neck, 1942 (Miss J.A. Fletcher), Q.V.M. Reg. No. 1942.13, (*b*) *Lt* 406, Binalong Bay, 18 June 1967 (Miss L. Webb), Q.V.M. Reg. No. 1967/5/12.

Dimensions. Values are given as *Tlt*, with absolute measurements, mm, in parentheses. Length to vent 448, 443 (142.5, 180), to dorsal origin 474, 457 (151, 190), to anal origin 454, 448 (144.5, 182). Head 73, 83 (23.1, 33.6). Snout 13, 17 (4.0, 6.7). Eye 3.5, 4.8 (1.1, 2.0). Interorbital 7.2, 12 (2.4, 5.0). Mouth cleft to angle of free gape 18, 23 (5.1, 9.5), to end of rictal groove 22, 30 (7.0, 12.0). Depth at back of eye 9.1, 15 (2.9, 6.10), middle of branchial sac 22, 25 (7.0, 10.5), gill opening 27, 27 (8.5, 11.3), vent 25, 30 (8.1, 12.0); maximum depth, head 27, 28 (8.5, 11.3), body 25, 30 (8.1, 12.0): width at same points 9.4, 14 (3.0, 5.7), 20, 20 (6.5, 8.0), 22, 25 (7.0, 10.0), 25, 26 (7.9, 10.6); maximum width, head 22, 25 (7.0, 10.0), body 26, 30 (8.2, 12.0).

Comparative proportions. Beyond noting the depth was about one-sixtieth, the head one-fifteenth of the length, and the length to the vent one-fourth less than that to end of tail, Macleay (1881, p. 272) gave no dimensions. However, in a redescription of the type, *Lt* 248, McCulloch (1911, p. 20) recorded some proportions; four of which, two with some amplification, are adopted in the diagnosis in the Handbook (Munro 1957a, p. 46). Values for some important ratios are here set out for the three Tasmanian specimens, in ascending order of *Lt*, followed in square brackets by some data from McCulloch and Munro. Depth in head —, (behind head, probably not maximum, 3.9) 2.7, 2.8 [3.3 behind gill opening, 3.9 behind vent, McC.; 3.3, M.]. Head in *Lt* 12.1, 13.8, 12.1 [13, McC., M.; fifteen, Macleay]; in trunk 4.1, 5.2, 4.4 [4.5, McC., 4.5-5.3, M.]. Eye in snout 5.3, 5.8, 5.0 ['nearly 3', McC., 3-3.3, M.]. Snout in head 5.3, 5.8, 5.0 [5.3, McC.]. Mouth cleft in head to end of rictal groove 2.8, 3.3, 2.8 [2.7, McC.], to end of free gape —, 4.3, 3.5. Length to vent in tail 1.39, 1.23, 1.26 [1.35, McC.; one and one-third, Macleay]. Distance of dorsal origin from vent, relative to head length, 0.13, 0.37, 0.30 head.

Schmidt's index. 1.10, 2.67, 2.46, all values negative.

SYNGNATHIDAE

MITOTICHTHYS Whitley, 1948

Mitotichthys Whitley, 1948, *Rec. Aust. Mus.*, 22(1), p. 75. Orthotype, *Syngnathus tuckeri* Scott.

Mitotichthys tuckeri (Scott, 1942)

Syngnathys tuckeri Scott, 1942, *Rec. Queen Vict. Mus.*, 1(1), p. 17, pl 5. Type locality: Bridport, northern Tasmania; netted in shallow water.

Mitotichthys tuckeri Whitley, 1948, *Rec. Aust. Mus.* 22(1), p. 75. *Id.* Scott, 1960, *Pap. Proc. R. Soc. Tasm.*, 94, p. 87.

Syngnathus tuckeri Munro, 1958, *Handbk Aust. Fish.*, 20, p. 82, fig. 568 *in Fisher. Newsl.* (now *Aust. Fisher.*), 17, 2. *Id.* Scott, 1964, *Pap. Proc. R. Soc. Tasm.*, 98, p. 93.

Generic status. See Part IX (1960, 87), Part XII (1964, 93): further consideration has led to the recognition here of the monotypic *Mitotichthys* Whitley, 1948. The chief points of distinction from *Syngnathus* Linné, 1758 are the location of the dorsal fin mainly on the trunk, and the much less extensive brood pouch (involving about 12, instead of 25 or more annuli). The relations of the present species with other Australian pipefishes should perhaps be the subject of further consideration.

New material. Data on five of the seven specimens that have previously come under the writer's notice, which are apparently the only examples in the literature, have been given in Parts IX, XII. Two additional examples, (*a*) *Ls* 77.0, *Lt* 80.4, (*b*) *Ls* 100.0, *Lt* 104.5, were collected at Low Head, northern Tasmania on 16 Feb 1974 by Mr R. Askeland; Q.V.M. Reg. No. 1974/5/100. This locality is in the same land division (formerly, county), Dorset, as the two localities (Bridport, Piper River Heads) from which four of the five earlier specimens came (remaining localities unknown); thus the species has yet to be reported from outside the eastern half of the island's northern coastline.

Meristic characters. Annuli 23+45, 23+43. Subdorsal annuli 10.0+2.0, 8.9+2.4. Brood annuli (*b*) caudal 0.1-12.5. D. 37, 36. P. 13, 13. A. ?, ?. C. 6, 6.

Dimensions and proportions. Measurements, mm, (in parentheses, values as *Tls*). Head

10.5 (136), 15.0 (150); length to origin of dorsal 25.1 (326), 31.2 (312), to termination 35.6 (461), 46.1 (461); dorsal base 10.5 (136), 14.9 (149); length to origin of brood pouch (*b*) 42.9 (429), to termination 57.5 (575); brood pouch base 14.6 (146); length to vent 32.1 (417), 42.0 (420); length of trunk 21.6 (281), 27.0 (270); length of tail 44.9 (583), 58.0 (580).

Measurements, mm (in parentheses, in head). Snout 5.0 (2.1), 7.6 (2.0); eye 1.3 (8.1), 1.9 (7.8); interorbital 1.0 (10.5), 1.4 (10.7); postorbital head 4.2 (2.5), 5.5 (2.7); longest dorsal ray 3.1 (3.4), 3.5 (4.3); length of pectoral 2.0 (5.3), 3.9 (3.8); oblique length of pectoral base 1.7 (6.2), 1.9 (7.9); depth at opercular margin 2.9 (3.6), 3.5 (4.3), at middle of trunk 2.1 (5.0), 3.0 (5.0), at middle of tail 1.1 (9.5), 1.8 (8.3).

Eye in snout 3.9, 4.0. Snout in head 2.1, 2.0. Head in trunk 2.06, 1.80. Trunk in tail 2.08, 2.15.

Conspectus values. A conspectus of Tasmanian syngnathids (Scott 1961) provides, as the first eight entries for each species, the minimum and maximum values recorded in the literature for a count or proportion. Values there given, as emended by the 1964 data, are noted below, with further increases in range necessitated by the present material added in parentheses. Total annuli 22-23+40-43 (45). Subdorsal annuli 9-10+1.9-3. Brood annuli caudal 1 (0.1)-12.8. Dorsal 32-36 (37). Eye in snout 3.1-3.7 (4.0). Snout in head 1.9-2.1. Head in trunk 1.9 (1.8)-2.2 (Handbook (Munro 1958a, p. 82) gives 3; perhaps head in length to vent intended). Trunk in tail 2.1-2.5.

Estimates of dimensions from regression equations. Regression equations of region (*Y*) on *Lt* (*X*) for eight regions, based on four individuals (together with correlation coefficient, measured and estimated values of regions; values of *t*) are set out in Part XII (table III, 94). Predicted values, mm, for the present two specimens are as follows: head 11.4, 13.8; snout 5.5, 6.6; eye 1.9, 2.1; postorbital head 4.1, 5.2; dorsal base 10.9, 13.4; length to vent 33.7, 41.6; trunk 22.2, 27.8; tail 46.7, 62.8. Comparison with measured values recorded above shows these estimates are in general tolerably good.

In the equation for the regression of snout on *Lt* given in table III (1964) the independent term should be positive; in the equation for eye on *Lt* three, not two, zeros should follow the decimal point (fortunately, the fact that both estimated and observed values are systematically recorded renders these typographical errors evident.).

Coloration. The holotype, preserved in alcohol, had most probably undergone considerable change in color before description: the present specimens provide some interesting information on the point. Some notes on coloration in the holotype are here followed, in parentheses, first, by observations made on this material when in a tolerably fresh state, secondly by observations made after upward of six months' preservation in alcohol. Ground color 'pale horn' mostly yellowish olivaceous or light olivaceous; later, yellowish, or pale yellowish green; 'a row of usually hemispherical whitish spots, one on each scute, along lower half of trunk' (spots lustrous silver; yellowish green: below midlateral ridge on anterior part of trunk an upper and a lower row of half-moons, their curved borders apposed); 'a whitish streak extending below eye along about one-third of infero-lateral angle of snout' (silver; light gold: this elongate pennon, starting from half an eye-diameter behind eye, covers whole of cheek below it, and runs forward, narrowing as it goes, for about two-thirds length of snout); 'dorsal and pectoral fins almost colorless' (dorsal faintly yellowish; yellowish in female, straw-colored with considerable streaky duskiness in male: pectoral almost colorless; golden or yellowish olivaceous).

In the present material the inferior border of the lateral surface of the tail

and both borders of the ventral surface carried a silver strip that after a period of preservation became pale gold.

Brood pouch. This is fully developed but empty. It shows no indication of regression, suggesting the loss of ova was recent (possibly on capture). In one fold, almost black externally, very dark grey internally, there are 15 subcircular or polygonal cells with low whitish membranous walls, mostly uniserial, but with 3 in an inner row near middle.

Published data on the breeding season of nine Tasmanian syngnathids have been summarized in Part XVIII (1971, p. 123). The entry there for the present species is, ovigerous, 4 November 1959 (IX 1960, p. 88), ovigerous November 1965 (unpublished); to which may now be added, pouch empty, apparently recently ovigerous 16 February 1974.

Family ZEIDAE

The Checklist (McCulloch 1929, p. 135) and the Handbook (Munro 1957d, p. 76) each give four species to Tasmania - *Zeus faber* Linne, 1758, *Zenopsis nebulosus* (Temminck and Schlegel,1845), *Cyttus australis* (Richardson,1843), *Cyttus novaezealandiae* (Arthur, 1885) [spelt *novaezelandiae* in Handbook], all of which have an extra-Australian range. Olsen (1958,p157) has added a fifth species, *Neocyttus rhomboidalis* Gilchrist, 1906, as *N. r.* Gilchrist, var. *gibbosus* McCulloch, 1914, record based on an example with anal spines III (species is quite unusual in having a variable anal spine count, III or IV), caught in 1951 on long line in 100 fms (*ca* 180 m) off Maria Island.

KEY TO ZEIDAE RECORDED FROM TASMANIA

1. Bony spinigerous bucklers on dorsal and anal profiles. Dorsal originating in advance of opercular border.....2
   No such bucklers. Dorsal originating behind opercular border.....3

2. Scales. Anal spines IV, last free from, or barely attached to, 1st ray, longest spine > (≐2) eye; anal rays 24 (21-23). Dorsal spines X; rays < 25 (22-24).....*Zeus faber*
   Scaleless. Anal spines III, last attached to 1st ray; longest spine < eye; anal rays ⩾ 25 (25-27). Dorsal spines VIII-IX; rays > 25 (27-28).....*Zenopsis nebulosus*

3. Anal spines III-IV, 1st spine > ½ (subequal to) ventral spine. Dorsal originating behind ventral. Eye very large, reaching profile, > (≐1½) first dorsal base.....*Neocyttus rhomboidalis*
   Anal spines II, 1st spine < ½ (≐1/8-¼) ventral spine. dorsal originating in advance of ventral. Eye large, but smaller, not reaching profile, ≤ first dorsal base.....4

4. Surface of scale with ridges and (in outer portion) spines, outer edge spinulate. Scales between lateral line and first dorsal > 12 (≐15).....*Cyttus australis*
   Surface of scale with ridges (may be denticulate) only, outer edge smooth. Scales between lateral line and first dorsal < 12 (≐9) *Cyttus novaezealandiae*

Genus *ZEUS* Linné, 1758

Zeus Linné, 1758, *Syst. Nat.*, ed. 10, p. 266. *Ex* Artedi, *Ichthy.*, 1738. Logotype, *Zeus faber* Linné.

E.O.G. Scott

Zeus faber Linné, 1758

Zeus faber Linné, 1758, *Syst. Nat.*, ed. 10, p. 267. *Ex* Artedi. Type locality: 'Habitat in Pelago.'
Zeus australis Richardson, 1845, *Zool. Voy. Erebus & Terror, Fish*, p. 36, pl. XXV, fig. 1. Type locality: Port Jackson, New South Wales.

Note on synonymy. The identity of the Australian and northern hemisphere fish, accepted in both the Checklist and the Handbook, whose example is here followed, is perhaps still open to some doubt. In his Name-list Whitley (1964, p. 41) recognises Richardson's species as the Australian form; he adopts the same name in his New Zealand Checklist (1968, p. 43).

Material. Whereas the silver dory, *Cyttus australis* (Richardson, 1843), is not infrequently submitted to the Museum for identification, examples of the John dory, like those of the New Zealand dory, *Cyttus novaezelandiae* (Arthur, 1885), are rarely seen. A small specimen, *Ls* 97.0, *Lt* 125.6 (species reaches a length of upwards of 600), taken off Ninth Island, northern Tasmania, on 8 September 1974 by Mr J. Shea (Q.V.M. Reg. No. 1974/5/166) exhibits some variation on the Handbook account (Munro 1957d, p. 76, fig. 527).

Fin counts. D. X,23. A. IV,23. P. 14/14. V. 1,7. C. 2+11+2.

Principal dimensions. Values are given as *Tls* (absolute, mm, in parentheses). Length to origin, termination of first dorsal 424 (41.1), 732 (71.0) (spine); second dorsal 754 (73.1) (ray), 925 (89.7); anal, spinous segment 597 (57.9), 714 (69.3) (spine); anal, rayed portion 746 (72.4) (ray), 899 (87.2). Length to pectoral 355 (34.4), length of fin 165 (16.0). Length to ventral 253 (24.5), length of fin 478 (46.4). Length to vent (middle) 517 (50.2). Longest dorsal spine 311 (30.2), same with membranous filament 546 (53.0). Longest ray of dorsal 124 (12.0), of anal 123 (11.9), of pectoral (5th) 144 (14.0), of ventral (4th from spine) 412 (40.0). Ventral spine 237 (23.0). Head 464 (45.0); snout, from tip of lower jaw (lip) 201 (19.5), from tip of upper jaw (lip) 186 (18.0), from most advanced point on preorbital 138 (13.4); eye 114 (11.1); interorbital 69 (6.7). Depth at front of eyes 402 (39.0), back of eyes 505 (49.0), operculum 588 (57.0), vent 603 (58.5); maximum depth 634 (61.5); depth of caudal peduncle 84 (8.1).

Other features. Maxilla to below 0.1 eye; its greatest width 2.80 its length, 237 (23.0). Lower jaw projecting beyond upper; two stout spines, diverging from common base, close below symphysis. Ventral extending to 2nd anal ray. Lateral line, particularly anteriorly, an almost continuous ridge, horizontal posterior segment, beginning about above 6th anal ray, 2.85 in chord of anterior segment, 448 (43.5). Almost exactly hemispherical 'thumb-mark' behind operculum by about one-third postorbital head; diameter, without whitish annulus 114 (11.1), with annulus 137 (13.3); midpoint collinear with upper anterior edge of preorbital and middle of caudal peduncle; central portion evenly black, presenting no sign of 'containing an irregular light-coloured figure' (Parrott 1959, p. 40). Marshall (1964, p. 133) observes, 'Small specimens differ from larger ones in having much deeper bodies, marked with many wavy lines from snout to tail.' Our example, with length about one-fifth that of a large individual, is not deeper than a normal adult. However, it exhibits a juvenile color pattern in the form of from ten to a dozen rather wide, not noticeably wavy, longitudinal lines on the flank, not clearly apparent in the figure by Waite (1921, fig. 113) of an adult, reproduced in the Handbook (fig. 525), and of which there are no signs in the colored illustration by Roughley (1916, pl. 58): compared with those in the color photographs by Doak (1972, pl. 7) of the New Zealand fish noticed by him under the name *Zeus japonicus*, the stripes here are wider than in his upper illustration, but noticeably less definite and less clearly continuous than in his lower illustration.

Comparison with Handbook diagnosis. Fin counts fall within the Handbook ranges. Values for our specimen of the four proportions given by the Handbook (its values in parentheses) are depth in *Ls* 1.58 (1.6); head in *Ls* 2.15 (2.2); eye in snout, from tip of lower jaw 1.76, from tip of upper jaw 1.68, from front of preorbital 1.21 ('eye in snout 1.2'); eye in head 4.05 (3.5). The Handbook notes of anal, 'spinous part separate' and Scott (1962, p. 97) stated 'The four strong anal spines are separated from the soft portion of that fin.' In the present example a small but distinct membranous sheet connects the base of the last spine with that of first ray.

Fin patterns. With more rays than the usual 5, the ventral fin takes on a pattern often found in a pectoral with relatively few rays (and in a short or moderate spinous dorsal), presenting one ascending series (lengths increasing) with log lengths a linear function of log serial number (N), and another series with log lengths yielding a linear graph when plotted against logs of inverse serial numbers (N^{-1}).

For subset rays 1-3 log L=0.8880 log N+1.1469; measured (predicted) lengths, mm, 14.2 (14.0), 25.1 (26.0), 38.0 (37.2); t=16.280. For subset rays 4-7 log L=0.1315 log N^{-1}+1.5207; 40.0 (40.0), 38.2 (38.5), 36.9 (36.4), 33.0 (33.2); t=11.389.

In the John dory all the dorsal spines are rigid, though, as in the silver dory, these are surmounted by long very flexible filamentous extensions. While the lengths of these cutaneous appendages are probably indeterminate, the spines proper follow a familiar length-number pattern, with an ascending N subset followed by a descending N^{-1} subset. For spines I-III log L=0.2724 log N+1.3554; spine lengths 22.5 (22.7), 27.9 (27.4), 30.2 (30.5); t=6.458. For spines IV-X log L=0.5175 log N^{-1}+1.0546; lengths 10.8 (11.3), 17.0 (16.2), 20.3 (20.0), 24.5 (23.3), 26.1 (26.1), 28.0 (28.7), 29.8 (31.0); t=18.968.

Unfortunately three of the four anal spines are imperfect.

Genus *CYTTUS* Günther, 1860

Cyttus Günther, 1860, *Cat. Fish. Brit. Mus.*, 2, p. 396. Logotype, *Capros australis* Richardson.

Cyttus australis (Richardson, 1843)

Capros australis Richardson, 1843, *Ann. Mag. Nat. Hist.*, 11, p. 170. Type locality: Port Arthur, Tasmania.

Species differentiation. In the course of preparation of the key given above it was noted some characters commonly treated as diagnostic do not always hold good. An examination of a series of 13 fish in the Queen Victoria Museum collection referred to *Cyttus* was accordingly undertaken, the following material being used (since the highly protractile mouth is more or less rigidly fixed in an extended condition in some individuals, rendering difficult an accurate determination of the whole length, two measurements of length of head, snouth, fish are here recorded, the first from anterior border of preorbital to hypural, the second, somewhat approximate, from tip of lower jaw; dimensions thus arrived at being designated short, full): (*a*) 106, 116, Tamar river, northern Tasmania, 24 June 1968, E.W. Gatenby, Q.V.M. Reg. No. 1968/5/28; (*b*) 119, 136, Tamar river, 24 June 1968, E.W. Gatenby, Q.V.M. Reg. No. 1968/5/29; (*c*) 146.5, 157, Beauty Point, Tamar river, 10 October 1965, E.W. Gatenby, Q.V.M. Reg. No. 1965/5/16; (*d*) 155, 166, northern Tasmania, 1930, T. Cannon, Q.V.M. Reg. No. 1937.87; (*e*) 172, 187, Anson's Bay, north-eastern Tasmania, 30 August 1969, G.A. Raynor, Q.V.M. Reg. No. 1969/5/27; (*f*) 183, 198, Bicheno, eastern Tasmania, 27 August 1972, Mrs D. Coles, Q.V.M. Reg. No. 1941.30; (*h*) 215, 226, off Cam river, north-western Tasmania, February 1973, H.J. Griffith, Q.V.M. Reg. No. 1973/5/30; (*i*) 223, 241, Tamar river, 23 October 1967, E.W. Gatenby, Q.V.M. Reg. No. 1967/5/28; (*j*) 256, 274, provenance not known; (*k*) 251, 269, Cape Lodi, eastern Tasmania, 13 May 1973, R.V. Bain,

Q.V.M. Reg. No. 1973/5/100; (*l*) 345, 370, Beauty Point, Tamar river, 20 June 1972, A.E. Meek, Q.V.M. Reg. No. 1972/5/744; (*m*) 440, 490, Burnie, north-western Tasmania, 6 February 1973, B. Thorp, Q.V.M. Reg. No. 1972/5/73.

Some basic dimensions and non-metrical characters are exhibited in table 2.

The diagnostic features noted for *C. australis* in the Handbook are as follows, the corresponding entries for *C. novaezealandiae*, where these differ, here being shown in parentheses: (1) depth in length without caudal 5.1.7 (1.6-1.7); (2) eye 2.75-3.2 (2.4) in head; (3) dorsal spines VII-X (VIII); (4) dorsal rays 28-33 (28); (5) spinous part of dorsal elevated (not much higher than soft part); (6) anal rays 31-37 (29); (7) fins pale carmine (spinous dorsal, ventral, caudal tip black) (8) ventral rays reaching 3rd anal ray (not reaching anal origin). Additional Handbook features relevant here are: (9) head 3 in length without caudal [both species]; (10) from figures 527, 528, caudal convex (emarginate); (11) eye greater than snout [both species]; (12) front part of each scale striated [noted for *C. novaezealandiae* only]. It may be observed that Stead (1906, 1908), Roughley (1916), Scott (1962) speak of the fins of *C. australis* as roseate, without direct mention of any black coloration.

Using the data of table 2, table 3 assesses the 13 specimens, assigning each of them to *C. australis* or *C. novaezealandiae* (or to both species, or neither), as determined on the basis of each of the 12 criteria listed in the preceding paragraph.

Proportions involving length of fish and length of head have been calculated twice, employing both the measurement from anterior border of preorbital and that from tip of lower jaw, and the two results are entered in the table (from an inspection of these it would seem evident the former mode of measurement is that adopted in arriving at the relevant Handbook proportions). For feature (9), relative length of head, the calculated value has been taken to be in agreement with the specified '3 in length without tail' when it is nearer to 3.0 than to 2.0 or 4.0. In an attempt to obtain some quantitative assessment of (5), the spinous dorsal has been taken to be 'elevated' (as specified for *C. australis*) if its longest element is (*a*) $\geq$2 longest dorsal ray, or (*b*) $\geq$2 in base of soft dorsal, measured directly with callipers. With regard to (12), not entered in the tables, it is to be remarked the anterior part of the scale is striated in both species; but only in *C. australis* is the posterior part furnished (as in all present material) with spines (McCulloch 1911, p. 87). It has not been found feasible satisfactorily to tabulate entries for 'dorsal profile concave above eyes' (listed for *C. novaezealandiae* only) in the absence of a more precise specification of the character. In general the section of the dorsal profile represented by the ends of the long backwardly-extending premaxillary processes is convex when these are retracted, but may appear concave when they are extruded; more ambiguously still, however, the degree of development (varying from very slight to considerable) of a short convex segment behind the eye results in the formation in advance of it of a local concavity, ranging from barely noticeable to quite pronounced, a feature that would or would not be regarded as significant according as the specification of a supraorbital concavity is interpreted.

Inspection of table 3 makes clear the inconstant, or otherwise unsatisfactory, nature of all or most of the characters there noted to which diagnostic significance has been attached in some published accounts — no specimen of the 13 examined being unequivocally identifiable, on the basis of these features, as *C. australis*, and all characters considered failing to prove critical in the case of one or more individuals. The low dorsal ray count, 26, of specimen (*a*) is quite exceptional. However, as noted above, all specimens are definitely determinable as *C. australis* by the nature of the scales, as reported by McCulloch; further, all are referable to this species by number of scales between lateral line and first dorsal base (15, McCulloch; our counts 14-17; *cf.* 9, McCulloch, in *C. novaezealandiae*).

Two items in table 2, not redacted in table 3, namely, bulk and rigidity of second large free dorsal spine, call for comment. While the first large free dorsal spine (commonly 3rd spine, 1st being separate, very small, 2nd frequently being much longer, more or less completely fused with first conspicuous spine) is in some few instances tolerably stout, and often exhibits at least basally, some rigidity, the spine immediately following it is characteristically slender, flexible: specimens (*j*) and (*l*) are exceptional in having the latter spine short, massive rigid, stone-like, similar to the preceding, suggestive of early spines of *C. novaezealandiae*.

Fin patterns. These have been investigated for the ventral fin in specimens (*j*),(*k*).

For (*j*) rays 2-6 on logs 1-5 give the equation log L=0.4334 log N^1+1.3015; measured (calculated) lengths, mm, 19.6 (20.0), 27.9 (27.0), 32.4 (33.2), 37.0 (36.5), 39.1 (40.2); t=19.129: for (*k*) log L=0.3582 log N^1+1.4124; lengths 26.0 (25.8), 32.9 (33.1), 38.2 (38.3), 42.2 (42.5), 46.5 (46.0); t=27.050.

In (*j*) the spine, ray 6, ray 5 yield a significant line (t=55.644) on logs 1-3, equation log L=0.1447 log N^A+1.5277; 33.5 (33.7), 37.9 (37.3), 39.1 (38.2), t=55.644: however, for (*k*) the equation log L=0.2686 log N^A+1.5448 has a t value of 8.420 only (i.e., probability of 0.1-0.5); lengths 34.8 (35.1), 43.1 (42.2), 46.5 (47.1).

Family KYPHOSIDAE

The Kyphosidae (not included in any published local list) have hitherto been known to be represented in Tasmanian waters only by *Kyphosus diemenensis* Scott, 1971, the unique holotype of which was described and figured in Part XVIII of these Observations. Two additional species, *K. sydneyanus* (Gunther, 1866), *K. gibsoni* Ogilby, 1912 are here reported. The three species are satisfactorily separable by the key to the Australian members of the family given earlier (1971, p. 134).

Genus *KYPHOSIS* Lacépède, 1802

Kyphosus Lacépède, 1802, *Hist. Nat. Poiss.*, 3, p. 114. Haplotype, *K. bigibbus* Lacépède.

Kyphosus sydneyanus (Günther, 1886)

Pimilepterus sydneyanus Günther, 1886, *Ann. Mag. Nat. Hist* (ser. 5), p. 18, p. 368. Type locality: Port Jackson.

Pimilepterus meridionalis Ogilby, 1887, *Proc. Zool. Soc. Lond.*, p. 539. Type locality: Port Jackson.

Tasmanian record. An example, *Ls* 215, taken at Croppies' Point, 28 December 1973, during the interstate spearfishing championships, provides the first record for this State; Q.V.M. Reg. No. 1974/5/163. The species has previously been known (Scott 1962, p. 193) from Western Australia, South Australia, New South Wales and Queensland.

Meristic characters. D. XI,12. A. III,11. P. 18/18. C. 18 (2 +14+2). V. I,5. Pierced scales of lateral line 54, of which 2 are beyond hypural joint. About 63 rows of scales above lateral line between its origin and hypural joint, the anterior ones irregular; 51 rows between posterior margin of supraclavicle and hypural joint. Scales between origin of dorsal fin and lateral line 10; about 24 more to ventral surface. Predorsal scales about 55, small and confused on occiput and nape; eight behind level of upper end of operculum, here tolerably regular. Gill rakers on lower anterior arch 15, slender, closely set, longest a little less than half longest gill filaments, about one-third eye.

TABLE 2

Cyttus australis (Richardson,1843). Some dimensions and other features of 13 Tasmanian specimens. 'Short; 'full' signify as measured from preorbital, from tip of lower jaw.
Key to symbols: E, emarginate; T, truncate or rounded; B, wholly or almost black; BW, approximately half black; b, touched with black; W, without black; S, slender; M, massive; R, rigid; F, flexible.

Feature	Specimen												
	(a)	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h)*	*(i)*	*(j)*	*(k)*	*(l)*	*(m)*
Short length	106	119	146.5	155	172	183	198	215	223	251	256	345	440
Full length (approx.)	116	136	157	166	187	198	211	234.5	241	269	274	370	480
Dorsal spines, number	VII	IX	IX	VIII	X	IX	IX	VIII	IX	VIII	VIII	VIII	VIII
Dorsal rays, number	26	29	29	29	30	29	29	31	29	31	31	30	31
Anal rays, number	29	29	30	29	31	30	31	31	28	30	31	30	31
Depth	69.5	75	87	94	104	110	122	126	115	140	127	181	197
Short head	32.5	30	44	47	50	55	59	67	55	71	73	101	144
Full head	42.5	47	54.5	58	65	70	72	78	73	89	92	126	184
Short snout	10.2	10	14.5	14	17	19	19	18	20.5	25	23.5	33	41
Full snout	20.2	27	25	25	32	34	32	37.5	38.5	43	42.5	58	81
Eye	12.1	13.2	15.0	17.1	16.5	18.5	20.0	21.5	18.3	25.0	23.3	32.1	37.6
First dorsal, base	46	50	63	66	73.5	77.5	106.5	95.5	83	106	96.5	145.5	150
First dorsal, color	BW	B	BW	W	BW	BW	BW	W	W	BW	W	W	W
Second large dorsal spine, bulk	S	S	S	S	S	S	S	S	S	M	S	M	S
Second large dorsal spine, rigidity	F	F	F	F	F	F	F	F	F	R	F	R	F
Longest dorsal spine	48.5	48.5	51+	57.5	81+*ca*10	66.5+	59+	67	89+	61	77.5	63	83
Longest dorsal ray	12.0	11.1	12.0	20.0	20.3	19.5	23.9	26.0	18.5	23.1	28.1	39.9	40.0
Ventral extending to (anal)	spine/ ray	2nd/ 3rd ray	1st spine	2nd spine	1st ray	2nd ray	2nd spine	-	1st ray	A-7mm	1st spine	A-10.5mm	A-7.5mm
Ventral, color	B	B	B	BW	B	BW	BW	-	BW	B	BW	BW	BW
Caudal, hind border, form	E	-	T	-	E	E	-	-	T	E	T	E	-
Caudal, hind border, color	B	-	b	-	B	b	-	-	W	B	B	W	-

TABLE 3

Cyttus australis (Richardson,1843). Determination, on the basis of several commonly employed diagnostic characters - *cf.* Handbook (Munro 1957b, p. 76, figs 527, 528) - of 13 Tasmanian specimens of this species. 'Short', 'full' signify as measured from preorbital, from tip of lower jaw.
A, *Cyttus australis;* N, *Cyttus novaezealandiae* (Arthur,1885); =, either species; X, neither species: blank cell, no datum available (specimen imperfect).

	Feature	Specimen												
No.	Specification	*(a)*	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h)*	*(i)*	*(j)*	*(k)*	*(l)*	*(m)*
(1a)	Depth in short length	A	=	=	=	=	=	X	=	X	X	X	X	X
(1b)	Depth in full length	=	X	X	X	X	X	X	X	X	X	X	X	X
(2a)	Eye in short snout	X	X	A	X	A	A	A	A	A	A	A	X	X
(2b)	Eye in full snout	X	X	X	X	X	X	X	X	X	X	X	X	X
(3)	Dorsal spines, number	A	A	A	=	A	A	A	A	A	=	=	=	=
(4)	Dorsal rays, number	X	A	A	A	A	A	A	A	A	A	A	A	A
(5a)	Spinous dorsal elevated, relative to dorsal rays	A	A	A	A	A	A	A	A	A	A	A	N	A
(5b)	Spinous dorsal elevated, relative to soft dorsal base	A	A	A	A	A	A	A	A	A	A	A	N	A
(6)	Anal rays, number	N	N	X	N	A	X	A	A	X	X	A	X	A
(7a)	Spinous dorsal, color	N	N	N	A	N	N	N	A	A	N	A	A	A
(7b)	Ventral, color	N	N	N	N	N	N	N		N	N	N	N	A
(7c)	Caudal, hind border, color	N		N?		N	N?			A	N	N	A	
(8a)	Ventral rays reaching to 3rd anal ray	N	N	N	N	N	N	N		N	N	N	N	N
(8b)	Ventral rays reaching to anal origin	A	A	A	A	A	A	A		A	N	A	N	N
(9a)	Short head in length	=	X	=	=	=	X	=	=	X	X	X	=	=
(9b)	Full head in length	=	=	=	X	=	=	=	=	=	=	=	=	=
(10)	Caudal, form of hind border	N		A		N	N			N	N	A	N	
(11a)	Eye, relative to short snout	=	=	=	=	X	X	=	=	X	X	X	X	X
(11b)	Eye, relative to full snout	X	X	X	X	X	X	X	X	X	X	X	X	X

Principal dimensions as *Tlt*. Total length 1233, length to end of middle caudal rays 1173. Length to origin, termination (base of spine) of first dorsal 330, 628; to origin, termination (bases of rays) of second dorsal 656, 828; to origin, termination of anal 628, 847. Length to origin of pectoral 233; length of pectoral, direct from most advanced point on base to tip of longest ray 195, or from middle of base to tip of longest ray, 174. Length to origin of ventral 340; length of ventral 205. Length to vent (middle) 591. Head 256; snout 65; eye 65; interorbital 116; internarial (anterior nostrils) 65. Depth (in parentheses width) at front of eyes 181 (112), back of eyes 279 (163), pectoral origin 391 (191), opercular margin 409 (205), ventral origin 437 (223), vent 451 (205); maximum depth (width) 465 (233); depth of caudal peduncle 142, width at anal termination 130, at hypural joint 47.

Length of ventral spine 111; of rays 1-5 109, 129, 167, 182, 172 [first ray here taken to be that furthest from spine (1974, 248): in description of holotype of *K. diemenensis* (1971p.137) series is given in reversed sequence]. Lengths of dorsal spines I-XI 33, 60, 89, 115, —, 125, 120, —, 100, 74, 52; of rays 1-12 72, 78, 91, 95, 101, 84, 91, 93, 102, 102, 107, 123. Lengths of anal spines I-III 49, 61, 71; of rays 1-11 82, 98, 106, 107, 98, 85, 84, 80, 84, 80, 92. Lengths of pectoral rays 1-17 80, 145, 167. 173. 169, 172, 169, 135, 149, 144, 133, 125, 112, 83, 74, 65, 56.

Comparative proportions. In the course of a detailed description, accompanied by an excellent figure, of an example 245 mm long from near Sydney McCulloch (1927, p. 56, pl. 11, fig. 2) noted a number of body ratios. Our values for these are subjoined (McCulloch's figures in parentheses). Depth before ventrals 2.29 (2.1) in *Ls*. Head 3.91 (3.6) in *Ls*. Breadth at pectoral bases 2.05 in depth there, or 2.44 in maximum depth (2.5 'in the depth'). Eye 1.00 in (shorter than) snout, 1.79 (1.7) in interorbital, 3.93 (3.9) in head. Interorbital 2.20 (2.1), snout 3.93 (3) in head. Depth of peduncle 1.09 (1.4) in its length, 1.80 (2.1) in head. Sixth dorsal spine 2.04 (2.9), second dorsal ray 3.27 (2.4), pectoral, from most advanced point on base direct to tip of longest ray 1.31, from middle of base to tip of longest ray 1.47 ('pectoral' 1.5) in head. McCulloch observed 'This young example differs considerably in its general form from larger examples 770 mm in length', noting in particular a decrease in relative depth with age.

General features. Head, trunk, tail in ratio 25.6:33.5:40.9. Diagnosis of body-form, in terms of the system of Gregory (1928), mesosomatic, gasterion preapical, apex median, gasterion median, hypsinotic, nomopygidial, opisthion preuranic.

Base of soft dorsal 0.58 base of spinous dorsal, measured between parallels. Pectoral reaching halfway along adpressed ventral, or to below dorsal spines V-VI. Ventral extending to below dorsal spines IX-X, failing to reach vent by an interval equal to that between vent and anal origin. Jaws equal anteriorly. Maxillary largely scaly, extending to just level of anterior border of orbit, its distal width 2.8 in its length, 0.9 its direct distance from eye. Teeth in jaws 24 above, 28 below; compressed, mostly subconical in outline, but several at ends of both series subtriangular or subrectangular.

McCulloch's observation (1927, p. 57), 'Anal a little farther back than the soft dorsal,' apparently refers to the rayed portion of the fin, his figure showing first anal spine about below last dorsal spine, as obtains in our specimen.

Coloration. General color olivaceous above lateral line, gradually lightening below to near ventral profile, there greyish. Ventral surface whitish, immaculate between just behind branchiostegal membrane and anal origin; in advance of this greyish, with small markings of darker grey, in general one on each scale; along anal base, like side of tail here, behind fin narrow immaculate strip of dirty whitish. On flank below horizontal level of upper orbital rim about 13 longitudinal rows of interrupted white or silvery stripes, constituted by short vertical lines or proconcave arcs (less conspicuous than in *K. diemenensis*); above level of orbit stripes inconspicuous, not

readily traceable. A prominent almost black spot, nearly one-third eye diameter, at lower border of pectoral base, constituting exposed extension of a dark bar, almost an eye diameter in vertical extent, about one-third this anteroposteriorly, mostly hidden beneath fin.

Head with lateral surface in general concolorous with flank; most scales on operculum, and, less conspicuously, those on preoperculum with lighter centre; opercular border blackish, width of band in upper segment about one-third, in lower segment about one-tenth, eye diameter; preoperculum with a somewhat dusky marginal strip virtually continuous with dusky upper lip; narrow dark arc behind, and reaching slightly above, eye, continued forward below rather more than posterior half of orbit.

First dorsal membrane largely greyish, with some blackish splashes; spines much like membrane, free tips usually blackish. Second dorsal mostly dark brownish; somewhat olivaceous, especially proximally. Anal rather like second dorsal, but lighter portion more extensive, up to two-thirds height of fin; tips of rays blackish. Pectoral chiefly greyish; briefly somewhat lighter proximally, this region followed by an obscurely defined arc somewhat darker than rest of fin. Ventral rays white or mostly whitish in basal half (first ray) or less than half, remainder ranging from dark brown to blackish; the basal white continued, except in first ray, along preaxial border of ray for from three-quarters to four-fifths of its length. Caudal greyish, somewhat olivaceous, proximally; distal half or so with some duskiness, deepest on middle rays.

Fin patterns. (See Introduction). In the present specimen rays V and VIII are imperfect, and no formulation is here suggested to include VI. Among the rest there can be recognised an ascending subset, comprising I-IV, and a descending subset, comprising VII-XI. For the former the best straight line for the regression of the logarithm of the length of the spine, L, on the logarithm of its serial number counting caudad, N, is log L= 0.8777 log N+0.8594: measured lengths, mm, (in parentheses, values predicted by equation) are 7.0 (7.2), 13.0 (13.0), 19.1 (19.0), 24.7 (24.4); t=4.823. For the descending subset log L=0.5165 log N^1+1.0574 [N^1= serial number counting cephalad]; 11.2 (11.4), 16.0 (16.4), 21.0 (20.1), 25.2 (26.2); t=14.010.

Anal spines - For the 3 anal spines log L=0.3336 log N+1.0191: 10.5 (10.5), 13.0 (13.2), 15.2 (15.1); t=16.350.

Pectoral rays - These increase in length to 4th, but this ray, somewhat unexpectedly, appears not to be an element of the ascending first subset, 1-3, but to belong to the lengthy descending subset 4-18. For rays 1-3, log L=0.6656 log N+12440: 17.5 (17.5), 28.0 (27.8), 36.3 (36.4); t=69.227. For rays 4-18 log L=0.7427 log N^1+0.7347: 5.0 (5.4), 10.0 (9.1), 12.0 (12.0), 15.0 (15.2), 18.1 (17.9), 21.0 (20.5), 23.0 (23.0), 27.0 (25.4), 28.9 (27.8), 30.1 (30.0), 32.4 (32.2), 34.5 (34.5), 36.0 (36.4), 37.0 (38.5), 38.1 (40.6); t=45.831. Though the overall fit for the descending subset of 15 rays is very good, yielding an extremely high t value, there is some suggestion the plot may not be strictly linear, a general concentration near the middle of the series of predicted values somewhat lower than measured lengths perhaps being indicative of a non-random slight curvature here: however, much of the total variation is attributable to two rays (8, 9), and the divergence from linearity may be non-significant. No comparable situation occurs in the subset of rays 4-19 in *P. gibsoni* noted below.

Ventral rays - No simple formulation (other than the obvious trivial one) involving spine and adjoining ray (5) has been found. For rays 1-4 log L=0.3747 log N+ 1.3694: 23.5 (23.4), 30.0 (30.3), 36.0 (35.3), 39.1 (39.4); t=37.468.

Kyphosus gibsoni Ogilby, 1912

Kyphosus gibsoni Ogilby, 1912, *Mem. Qld Mus.* 1(1), p. 50. Type locality: Moreton Bay.

Tasmanian record. *K. gibsoni* is reported in the Check-list (McCulloch, 1929, p. 238) from Queensland only. A Tasmanian example, *Ls* 262, netted by Mr T. Jenkins at Norfolk Bay, 13 May 1974, Tas. Mus. Reg. No. D. 1209, has been made available for examination through the much-appreciated good offices of Mr A.P. Andrews, Curator of Vertebrates, Tasmanian Museum, Hobart, and by his courtesy for notice here. The original description of the holotype from Queensland by Ogilby (1912) was later supplemented by an account and a figure of it by McCulloch (1929). Little or no additional original morphological data on the species appears to be available; accordingly, a tolerably full account of the Tasmanian example is here offered.

Meristic characters. Values for the holotype, as given by Ogilby and later by McCulloch, where different from present figures, are noted in square brackets. D. XI,14 [XI,13 Ogilby]. A. III,12. P. 19/19 [18, Ogilby]. V. I,5. C. 1+15+1 [not recorded; 15]. Pierced scales of lateral line 58, of which 6 are beyond hypural joint [59 (6); 54]; about 67 [78, 75] rows of scales above lateral line between its origin and hypural joint; about 57 [68, 62] between posterior margin of supraclavicle and hypural joint (in both cases anterior scales somewhat irregular); l. tr. 11/23 [12/21; 12/21]. Predorsal scales about 60, small and confused on dorsum of head, 21 beyond level of upper angle of operculum [not recorded].

Principal dimensions as *Tls*. Total length 1302 (tip of upper caudal lobe), 1252 (tip of lower caudal lobe); length to end of middle caudal rays 1145. Length to origin, termination (bases of spines) of first dorsal 355, 582; to origin, termination (bases of rays) of second dorsal 594, 874; to origin termination of anal (spine, ray bases) 607, 866. Length to origin of pectoral 229; length of fin, direct from most advanced point on base to tip of longest ray 183, from middle of base to tip of longest ray 164. Length to origin of ventral 305; length of fin 179. Length to vent (middle) 561. Head 244; snout 73; eye 62; interorbital 108; internarial (anterior nostrils) 71. Depth (in parentheses width) at front of eyes 160 (107), back of eyes 239 (130), pectoral origin 326 (153), opercular border 343 (156), ventral origin 382 (176), vent 405 (157); maximum depth (width) 447 (176); least depth of caudal peduncle 111, depth at end of dorsal 160, width at anal termination 94, at hypural joint 34.

Length of ventral spine 76; of rays 1-5 86, 100, 148, 168, 172. Lengths of dorsal spines I-XI 21, 38, 61, 75, 97, —, —, 111, 101, 93, 74; of rays 1-13 103, 100, 97, 89, 88, 80, 80, 76, 76, 73, 67, 65, 69 (anterior ramus) or 81 (posterior ramus). Lengths of anal spines I-III 30, 45, 54; of rays 1-12 123, 129, 107, 103, 95, 94, 88, 76, 72, 69, 66, 69 (anterior ramus) or 84 (posterior ramus). Lengths of pectoral rays 1-19 53, 137, 164, 170, 164, 156, 147, 137, 130, 123, 118, 104, 99, 89, 79, 72, 58, 46, 31.

Comparative proportions. Ogilby (1912) noted 16 length ratios of the holotype and McCulloch (1929) 13 of the same specimen; some of those common to the two accounts exhibiting some difference. A comparative summary of the two sets of data reported for the holotype and values for the present example follow, Ogilby's figures being cited first, those for the Tasmanian fish last. Ogilby's 'length of body' is here assumed to signify standard length.

Maximum depth in *Ls* 2.33, —, 2.24. Depth before ventrals in *Ls*, —, 2.6, 2.62; 'breadth before pectorals in depth' —, 2.1, 2.13 (depth before pectorals) or 2.93 (maximum depth). Head in *Ls* 4.2, 4.08, 3.91. Eye in snout 1.3, 1.1, 1.7; in interorbital 1.85, 1.8, 1.74; in head 3.9, 4.3, 4.13; in depth of cheek below eye 1.1, —, 1.30. Interorbital in head 2.1, 2.3, 2.38. Snout in head 3.05, 3.7, 3.53. Depth of caudal peduncle in its length (measured in our example to hypural joint) —, 1.7, 1.14; in head —, 2.4, 2.31; in depth of body 4.25, —, 4.03. Pectoral in head — 1.6, from most advanced point on base direct to tip of longest ray 1.33, or from middle of base to tip of longest ray 1.49; in *Ls* 6.25, —, 5.46 or 6.04. Ventral in *Ls* 6.5, —, 5.57. Caudal in *Ls* 3.65, —, 3.97. Dorsal spine in head 2.15 (longest), 2.3 (6th), 2.20 (8th, longest intact; 6th and 7th imperfect) or 2.53 (5th). First dorsal ray in head

2.7, —, 2.67. Longest anal in head 3.9, —, 4.54. Posterior anal rays in anterior 1.55, —, 1.45. Width of distal extremity of maxillary in its length 2.66, —, 2.96, or —, —, 1.13 its direct distance from eye.

General Description. Head, trunk, tail in ratio 25.6:30.5:43.9.

Body broadly elliptical; dorsal profile a trifle more arched than ventral; compressed, greatest width 2.3 in greatest depth; head obtuse, its depth at front of eyes 1.6, at back of eyes 1.1, at opercular margin 0.74, in its length. Dorsal profile, as constituted by upper lip and adjoining segment, extending about two-thirds width of lip, moderately convex, a minor dip at junction of the two regions; immediately following, about at level of two-thirds of length to anterior nostril, abruptly, but briefly, steeper; thereafter to highest point, at level of last one-third of first dorsal base, a tolerably even convex sweep, slightly depressed at occiput, its chord about 25° to horizontal; thence descending, in a similar curve, to end of soft dorsal before gradually easing out on caudal peduncle. Ventral profile to end of anal base an essentially continuous curve; behind vent similar to dorsal profile there, in advance of vent a little less convex, especially in hinder half of trunk. Caudal peduncle short, fairly stout, its greatest depth 1.4 its least, latter 1.1 in peduncle length or 2.0 in head. Eye extending into hind half of head by about one-tenth of its own diameter, its highest point below dorsal profile by a little less than two-thirds its diameter, the diameter 1.3 in depth of cheek vertically below orbit. Preorbital, dorsum of snout to level of anterior nostril, chin to same level, lips, naked; these areas covered with minute vermicular elevations, and, except for lips, sprinkled with small pores. Anterior half of preorbital border entire, posterior half with small rather obscure crenulations, about 8 on right side, half as many on left; integument obscurely ridged. Nostrils approximate, interval between them subequal to diameter of anterior, about half distance of posterior from orbit; the anterior a vertically elliptical opening with slightly elevated margin, its distance from its fellow subequal to its distance from middle of eye, or from middle of margin of upper lip; the posterior a backwardly and upwardly oblique elliptical aperture, with low skinny lips, its opening continued backwards for a distance about equal to its major axis by a naked groove, progressively shallower backward. Preopercular border fluted and obscurely crenulated, most markedly at and near angle. Posttemporal obscurely crenulated. Operculum with two weak spines, one slightly above level of orbit, one about level with lower border of pupil. Maxillary mostly squamous, marginally naked; extending beyond level of anterior nostril, just failing to reach eye; its distal width one-third of its length, equal to its least distance from orbit. Upper jaw barely in advance of lower. Lips broad, with characteristic generic form, width of upper half its length: a line from upper border of upper lip to base of last dorsal ray passes across middle of eye. Teeth in jaws glassy, in single series, 22 in upper, 26 in lower; most contiguous basally, rest virtually so; compressed, general outline approximating three-fifths of an ellipse, the apex well rounded, but three or four lateral teeth in each side of lower jaw somewhat more squarish; whole series regularly decreasing in size outwards. Minute teeth on vomer in a transverse elliptical patch; on each pterygoid in a longitudinal elliptical patch; on anterior part of each palatine in a small group; on tongue, somewhat in advance of middle of its length, in a very broad proconvex arc, extending virtually whole width of tongue here, these teeth, like those on palate, yellowish. Gill rakers on lower limb of anterior arch 22, rodlike, slender, increasing in length forwards, longest less than half gill filaments, about one-third eye.

Body covered with ctenoid scales, which extend on to most of head (see above), and almost entirely sheath soft dorsal and anal, barely encroaching, however, on bases of dorsal or anal spines. Entire pectoral base, whole length of lower rays, proximal half, or so, of middle rays covered with small scales similar to those on vertical fins. Base and most of length of ventral rays scaly. Proximal one-fourth of caudal covered with integument, the hinder border proconcave, bearing scales continuous with, but backwardly progressively smaller than, those of caudal peduncle; still smaller scales extending up the rays, in some cases for virtually their whole length. Lateral

line closely following curve of back to end of spinous dorsal, its direct distance (callipers) here from base equal to postorbital head; caudad of this progressively approaching dorsal profile, its direct distance from this at end of soft dorsal base two-thirds that at beginning of that base; on caudal peduncle a little nearer dorsal than ventral profile. Openings on pierced scales circular or subcircular anteriorly, slit-like posteriorly.

Dorsal commencing above middle of pectoral, behind insertion of ventral by two-thirds snout length; margin of spinous portion fairly evenly arched, but last spine more than three and a half times first, longest intact spine (VIII) 1.1 longest (1st) dorsal ray; margin of soft dorsal very slightly convex, rays decreasing in length from 1st to 5th, latter 1.2 in former, showing little variation in length from 6th to 8th, measureably decreasing again to 12th, 1.6 in 1st, the 13th increasing to 1.5 (anterior ramus) or 1.3 (posterior ramus) in 1st; rayed base longer than spinous base, latter, measured between parallels 1.24, directly with callipers 1.32, times former. Anal much like soft dorsal, but a little higher anteriorly, 1st ray 1.2 1st dorsal ray; originating about below 2nd dorsal ray, terminating virtually evenly with dorsal; base 1.08 soft, 0.88 in spinous, dorsal base; 3rd spine 1.2, 2nd 1.8 1st, the last-mentioned 8.5 in head; 2nd ray longest, 2.0 in head, then decreasing to 11th, 1.9 in 2nd, the last ray longer, its anterior ramus 1.87, its posterior 1.53 in 2nd. Pectoral base well in advance of dorsal and ventral origins, set at about 45°, its oblique extension subequal to eye; fin short, broad, ovate; extending to below dorsal spines V/VI; length from most anterior point of base to tip of longest ray 1.6, length from middle of base to tip of longest ray 1.8, in head; longest (4th) ray 1.6, a trifle shorter than longest ventral ray; first two rays unbranched. Ventrals originating behind pectoral base by an interval subequal to anteroposterior extension of that oblique base; failing to reach vent by an interval equal to that between vent and anal origin; longest ray (5th, adjacent to spine) 1.5 in head, 2.3 spine. Caudal deeply emarginate, anteroposterior extension of tip of upper lobe beyond tips of middle rays equal to that of middle rays beyond hypural; length 3.32 in *Ls*; lobes pointed, upper extending beyond lower by nearly an eye diameter; caudal ridges well developed, oblique length from origin of upper to tip of upper lobe 1.36 head.

Immediately internal to ventral base a small, wholly separate pennon-like axillary lobe, its outer border 1.6 in inner border plus base; this combined length 5.2 basal width or about four-fifths eye.

Coloration, as preserved. Lateral and dorsal surfaces of body dark olivaceous brown above, at its deepest approaching black; below midlateral line lightening somewhat, most markedly in lowest one-fourth, with some silvery tinge here derived from the scale markings; ventral surface ranging from whitish or pearly to isabelline. In lowest six or seven rows each scale with a large elliptical or pyriform light, more or less pearly marking, its major axis sloping backwards and upwards; the light broken lines thus formed not being recognizable above level of upper end of pectoral base, two just being traceable on caudal peduncle: above midlateral line uniformly dark.

Head with dorsal surface and lateral surface down to level of superior border of orbit very dark, concolorous with dorsum and upper part of trunk; below this gradating on cheek to dark brown; an arc of lighter brown behind eye, continuing forward on to hinder part of band of smooth integument joining eyes above upper lip, middle of this band darker; operculum narrowly bordered with dark fawn, membrane mostly blackish; preoperculum margined with dark fawn, narrowly posteriorly, more widely but more obscurely ventrally; narrow exposed strip of interoperculum light and dark brown with some small pearly spots; upper lip about concolorous with scaleless strip above it; lower lip more or less slaty, darkest along upper border; isthmus noticeably lighter than adjacent parts, approaching whitish, with faint silvery tinge. Preserved portions of membrane of spinous dorsal dull violescent; exposed parts of spines white. Rayed dorsal and rayed section of anal almost uniform dark brownish, a trifle lighter distally, last anal ray lighter with some yellowish; membrane investing most of spines II and III

about concolorous with that of rayed part of fin, membrane investing spine I light fawn; briefly exposed tips of spines vitreous. Pectoral with narrow basal arc of dusky chestnut; rays thereafter dark brown about up to a proconcave arc from near base of lowest ray to distal one-fifth of longest (4th) ray; distad of this dusky silvery. Proximal half or so of ventral plumbeous; rest dark brown, approaching black at tip. Caudal not greatly different from anal and soft dorsal, but upper and lower rays tending to be somewhat lighter, middle rays somewhat darker.

Fin patterns. Dorsal spines VI, VIII are imperfect: the rest constitute one ascending subset, I-V, and one descending subset, VIII-XI. For the former log L=0.9607 log N+ 0.7273: measured lengths, mm, (in parentheses, values from equation) 5.4 (5.3), 10.0 (10.4), 16.0 (15.3), 19.7 (20.2), 25.3 (25.1); t= 17.310. For the latter log L=0.2837 log N^1+1.2992: 19.5 (19.9), 24.4 (24.0), 26.5 (26.7), 29.1 (28.8); t=5.199.

Anal spines - log L=0.5315 log N+0.9005: 7.9 (8.0), 11.7 (11.5), 14.1 (14.3); t=19.645.

Pectoral rays - As in *K. sydneyanus*, these increase in length to 4th, but again this ray is a member of the descending subset. For rays 1-3 log L=0.6127 log N+1.3247: 21.0 (21.1), 32.8 (32.3), 41.0 (41.4); t=24.898. For rays 4-19 log L=0.6155 log N^1+ 0.8946: 8.0 (7.8), 12.0 (12.0), 15.1 (15.4), 18.8 (18.4), 20.8 (21.1), 23.3 (23.9), 26.0 (26.9), 27.3 (28.2), 30.9 (30.3), 32.2 (32.4), 34.1 (34.3), 36.0 (36.1), 38.6 (38.0), 40.8 (39.8), 42.0 (41.5), 43.0 (43.2); t=61.532.

Ventral rays - For rays 1-4 log L=0.4862 log N+1.5593: 22.5 (22.9), 33.0 (32.0), 38.9 (39.0), 44.1 (44.8); t=18.805.

Remarks. *Kyphosus gibsoni* is separable at sight from *K. sydneyanus* and *K. diemenensis* in having soft dorsal base exceeding spinous dorsal base, the former being about 0.58 of the latter in the first of these two species, about 0.74 in the second.

As the items of comparative quantitative data presented above make evident, the Tasmanian fish agrees in general quite well with the holotype as described by Ogilby, and redescribed and figured by McCulloch. While Ogilby observed 'sides with 8 bronze-gold bands, about a third of a scale in width, and confined to the upper and lower edges of the mid-lateral series of scales', and while McCulloch's plate appears to show upwards of a dozen bands on flank below lateral line, these light longitudinal bands are confined in the present specimen to side below level of upper end of pectoral base. The brief, but pronounced, elevation in dorsal profile before eye in our fish is scarcely indicated in McCulloch's figure of this species (1929, pl. XII, fig. 3), and is more conspicuous, and noticeably more abrupt anteriorly, than in the figure of *K. sydneyanus* on the same plate. Ogilby observes 'tongue smooth.' However — not unexpectedly, in view of the presence of lingual teeth in *K. sydneyanus* (holotype of *K. diemenensis* has tongue damaged) — the tongue, as noted above, here bears a wide cross-band of minute yellow teeth.

Family ENOPLOSIDAE

Genus *ENOPLOSUS* Lacépède, 1802

Enoplosus Lacépède, 1802, *Hist. Nat. Poiss.*, 4, p. 540. Haplotype, *E. white* Lacépède = *Chaetodon armatus* White.

Enoplosus armatus (White, 1790)

Chaetodon armatus White, 1790, *Voy. N.S. Wales*, p. 254, fig. 1. *Ex* Shaw MS. Type locality: New South Wales [Checklist specifies 'Between Broken Bay and Botany Bay'].

Juvenile material. This species has been the subject of notice in Part XIX (1974a, p. 268), where some general observations are made on synonymy, venomous dorsal spines (*cf.* Scott 1970b, p. 239) and distribution; and a sample of six individuals, comprising one young, *Ls* 52.1, and five adult, *Ls* 161.7-221.0, is examined, a table of dimensions being provided, and some discussion of differnetial growth undertaken. The collection by Mr R. Askeland at Low Head, northern Tasmania, on 16 February 1974 of a sample of 29 very small individuals, all with *Ls* under 30, affords a fortunate opportunity to record the (highly characteristic) juvenile coloration, and to confirm and extend earlier conclusions on relative growth at various morphological landmarks along the general anteroposterior axis.

Specification of *Ls*. For the whole sample (29) the range of *Ls* is 13.4-29.1, with mean 24.27 ± 0.79 (*s* 4.27 ± 0.56, *V* 17.6 ± 2.4). The large coefficient of variation points to probable heterogeneity, and inspection of the frequency distribution — in 1 mm classes, 1, 1, 0, 1, 1, 0, 1, 0, 1, 0, 0, 5, 2, 6, 4, 4, 2 — suggests the possible existence of two populations, one of 23 individuals of *Ls* 23.6-29.1, $\bar{x}$ 26.23 ± 0.34 (*s* 1.63 ± 0.23, *V* 6.2 ± 1.0) the other of 6 individuals of *Ls* 13.4-19.3, $\bar{x}$ 16.79 ± 1.07 (*s* 2.61 ± 0.75, *V* 15.6 ± 4.6). A formal test of the significance of the difference of the means yields *t* 10.602**.

Specification of *Lt*. For the whole sample *Lt* is 17.0-36.2, $\bar{x}$ 30.85 ± 1.01 (*s* 5.43 ± 0.71, *V* 17.7 ± 2.4), for 23 larger specimens 31.8-36.2, $\bar{x}$ 33.40 ± 0.34 (*s* 1.63 ± 0.24, *V* 4.9 ± 0.7), for 6 smaller specimens 17.0-24.4, $\bar{x}$ 21.08 ± 1.43 (*s* 3.5 ± 1.01, *V* 16.6 ± 5.1).

Dimensions as *TLs*. About a score of measurements was made of each of 10 individuals: these dimensions, expressed as millesimals of standard length, are set out in table 4, together with *Ls*, mm, (first line of table). Entries in the righthand column of the table showing the number of measurements falling within $\bar{X} \pm s$ make it evident the distribution of the varieties is tolerably symmetrical.

Also, measurements of *Ls*, *Lt*, head, eye, maximum depth (only) were made of the remaining 19 specimens. Values of *Ls* and *Lt* for the full series of 29 have been given above. For 29 examples *TLs* specifications are: head 388-504, $\bar{x}$ 435.1 ± 5.39 (*s* 29.00 ± 3.81, *V* 6.7 ± 0.9); eye 103-149, $\bar{x}$ 121.6 ± 1.92 (*s* 10.33 ± 1.36, *V* 8.5 ± 1.1); maximum depth 357-592, $\bar{x}$ 417.6 ± 7.74 (*s* 41.70 ± 5.47, *V* 10.0 ± 1.3); caudal (*Lt* − *Ls*) 187-339, $\bar{x}$ 269.5 ± 6.3 (*s* 34.14 ± 4.48, *V* 12.7 ± 1.7).

Variation in relative size of certain regions with *Ls*. In part XIX (1974a) a table of dimensions of 6 individuals of *Ls* 52.1, 161.7, 182.0, 185.0, 200.0, 221.0 was given, and the variation in relative lengths of certain regions compared with overall length was investigated by consideration of the relevant *TLs* values with *Ls*. Comparison of the present data with data for the larger examples yields the following interesting information on relative growth.

For lengths, from tip of snout, as millesimals of *Ls*, to 8 points lying in sequence caudad along antero-posterior axis of fish (end of snout, ventral origin, end of head, dorsal origin, vent, anal origin, dorsal termination, anal termination) the mean values in 6 large individuals (derivable from 1974 table) are 73.4, 79.0, 79.5, 84.1, 92.0, 91.9, 99.2, 99.7 per cent of mean values (exhibited in present table) in 10 small individuals. Specimen (*a*) of the 1974 material stands well apart from the rest, its length being less than one-third that of the next smallest example: with this individual excluded, corresponding values for the 5 individuals are, in general, predictably somewhat smaller: 70.8, 76.7, 77.9, 82.7, 90.2, 90.7, 99.5, 99.5. It will be seen that, with minor exceptions (fractional deficit for vent in first set, equality of last two entries in second set), both series increase in magnitude caudad, that is, the anterior region contributes more to overall length in the juvenile than in the adult, the magnitude of the excess progressively decreasing backward. It is to be

noted differences between *Tls* means for 10 juveniles and 6 adults for these points are statistically significant as far back as anal origin; however, at the last two points, for which the difference of the means is only a fraction of one percent, *t* falls below unity (not unexpectedly, in view of normal individual variation in both series).

The resultant morphological picture can conveniently be presented thus: the percentages of standard length represented by head, trunk, tail are in the 10 juveniles 42.3, 15.2, 42.5, in the 1974 material 33.6, 19.3, 47.0.

For the combined 1974 sample and present material correlations of *Tls* values with *Ls* are as follows. Head $r - 0.900$ (z 1.472), t 7.726**, trunk r +0.423 (z 0.453), t 1.743; tail r +0.733 (z 0.934), t 4.028**. While for trunk length the correlation is not statistically significant, it is so for length to vent r −0.752 (z 0.979), t 4.275**.

Bases of vertical fins. It has already been established that there are high correlations with *Ls* of length (between parallels) of *Tls* of dorsal base (r 0.964) and anal base (r 0.958). Values of *Tls* for present 10 juveniles, small 1974 individual, other 5 1974 individuals are for dorsal base 396.2 ± 8.72, 421, 471.0 ± 1.96; for anal base 237.5 ± 7.19, 245, 285.6 ± 4.68.

Relative lengths of spines and rays. In general (dorsal an exception) the relative lengths (*Tls*) of longest spines and rays of fins for which comparative measurements are available show an increase with length of fish: however, it should be noted samples are small and dispersion is large. Mean *Tls* values in the three groups of 10, 1, 5 individuals specified above are shown below.

Longest dorsal spine	292.7 ± 16.0	344	280.4 ± 7.56
Longest dorsal ray	265.1 ± 20.2	378	604.3 ± 76.7 (4 only)
Longest anal spine	146.5 ± 4.83	—	163.8 ± 6.30
Longest anal ray	231.9 ± 12.8	288	370.4 ± 20.1

With the single 1974 specimen pooled with the rest of that material, mean value for longest dorsal spine is 291.0 ± 11.6, *i.e.*, virtually identical with that for the ten small individuals.

Juvenile coloration. These very young fish differ markedly in general appearance from adults, most strikingly so in the regular presence on head and trunk of discrete, well-defined patches, usually more or less rounded, of shining silver, producing overall a conspicuous and highly characteristic color pattern.

One constant silver patch occurs below the eye, regularly occupying whole area between it and lower border of preoperculum, reaching forward to, or beyond, level of anterior border of orbit, backward to posterior preopercular border; this marking, modally subelliptical, occasionally develops at its hind end an upward extension that may fill whole space between posterior borders of orbit and preoperculum; it is constantly traversed by a rather narrow brown bar, running a little obliquely downward and backward from lowest point on orbit to lower margin of preoperculum. Other discrete, coin-like silver markings almost invariably present include one large one below pectoral base, in some instances encroaching on base, and in most individuals continuing down to ventral profile of fish; two spots, fairly large but smaller than first on trunk, lying along ventral profile between that marking and anal origin: these three trunk markings about equally spaced. In some individuals additional, less conspicuous silver spots occur.

First dorsal usually more or less dusky anteriorly, whitish posteriorly. Second dorsal spine yellowish, somewhat dusky; first half dozen rays ranging from dark brown to black, membrane here yellowish; other rays and their membrane white. Anal spines

TABLE 4

Enoplosus armatus (White, 1790). Dimensions of ten juveniles, Low Head, northern Tasmania. First line of dimensions absolute, millimetres; other lines relative, millesimals of standard length.

Feature	Range	$\bar{x}$	s	V	$\bar{x} \pm s$ [normal curve, 7]
Standard length	25.4 - 29.1	27.17± 0.42	1.33± 0.297	4.9±1.1	6
Length to origin of dorsal	402 - 485	458.9 ± 7.3	23.1 ± 5.15	5.0±1.1	7
Length to termination of dorsal	828 - 869	855.1 ± 3.8	12.1 ± 2.70	1.4±0.32	7
Length to origin of anal	606 - 674	629.7 ± 7.5	23.8 ± 5.31	3.8±0.84	8
Length to termination of anal	822 - 888	860.6 ± 5.8	18.2 ± 4.08	2.1±0.47	8
Length to origin of ventral	317 - 391	360.6 ± 7.1	22.5 ± 5.04	6.2±1.4	7
Length of ventral	271 - 428	321.7 ±10.2	43.1 ± 9.63	13.4±3.0	7
Length of pectoral	254 - 396	313.4 ±15.8	50.0 ±11.2	16.0±3.7	8
Length of caudal	187 - 287	248.7 ±10.0	31.6 ± 7.06	12.7±2.9	6
Length to vent	551 - 629	575.5 ± 8.0	25.3 ± 5.66	4.4±0.99	8
Head	388 - 471	423.2 ± 7.9	24.9 ± 5.56	5.9±1.3	7
Snout	103 - 136	120.3 ± 2.8	8.75± 1.96	7.3±1.6	7
Eye	103 - 149	117.1 ± 3.9	12.3 ± 2.74	10.5±2.4	8
Interorbital	73 - 101	89.6 ± 4.1	12.8 ± 2.87	14.3±3.3	7
Maximum depth	378 - 447	416.8 ± 6.5	20.4 ± 4.57	4.9±1.1	6
Depth of caudal peduncle	119 - 155	132.5 ± 3.3	10.4 ± 2.33	7.9±1.8	7
Length of longest dorsal spine	235 - 430	292.7 ±16.0	50.6 ±11.2	17.3±4.0	8
" " " " "					
omitting No. 2 (430)	235 - 311	277.4 ± 7.7	23.0 ± 5.42	8.3±2.0	7 [normal curve, 6]
Length of longest dorsal ray	221 - 450	265.1 ±20.2	63.7 ±14.3	24.0±5.8	9
" " " " "					
omitting No. 2 (450)	221 - 268	244.6 ± 5.7	17.1 ± 4.04	7.0±1.7	4 [normal curve, 6]
Length of first anal spine	47 - 106	85.8 ± 4.4	14.0 ± 3.12	16.3±3.7	6
Length of second anal spine	108 - 147	132 ± 4.0	12.7 ± 2.83	9.6±2.2	6
Length of third anal spine	122 - 176	146.5 ± 4.8	15.3 ± 3.42	10.0±2.4	7
Length of longest anal ray	144 - 298	231.9 ±12.8	40.6 ± 9.07	17.5±4.0	7

reddish yellow or whitish; rays and their membranes like those of dorsal. Pectoral virtually colorless, faintly whitish, faintly greenish, or faintly greenish yellow. Ventral spine greenish, at times somewhat reddened; rays black or nearly so. Caudal colorless save for two contiguous greenish brown half-circles at hypural.

Family KATSUWONIDAE

The family Katsuwonidae, recognised as such in the Handbook (Munro 1957b, p. 114), is included by some writers (*e.g.*, Jordan 1923, McCulloch 1929, Scott 1962) in the Thunnidae, *sensu stricto* (*i.e.*, with exclusion of the mackerels), while others treat it as part of a larger assemblage, *e.g.*, the Thunnidae, *sensu lato* (Berg 1940) or the Scombridae (Greenwood *et al.* 1966). Of the 5 Australian species, referred to 4 genera, listed in the Handbook, 2 species, representing 2 genera, have been reported from Tasmania: *Auxis thazard* (Lacépède, 1802), *Katsuwonus pelamis* (Linné, 1758), separable by the subjoined key.

KEY TO KATSUWONIDAE RECORDED FROM TASMANIA

A. D.X-XII, 12. Dorsal fins separate; interdorsal $\geq$ ½ head. Gill rakers on anterior arch 10-11+28-32. Plumbeous or dark bluish above, silvery below; mackerel-like pattern of dark wavy lines and blotches on back and upper flank.....*Auxis thazard*

AA. D.XIV-XVI, 14-16. Dorsal fins joined, though in part by a mere slip of membrane that may be largely adnate to back; pseudo-interdorsal, between elevated parts of fins, $<$ ¼ head. Gill rakers on anterior arch 17-21+33-42. Uniform dark color, bluish or blackish, often with purplish and/or greenish sheen above, silvery below; about 5 dark grey longitudinal stripes along lower half of flank.....*Katsuwonus pelamis*

KATSUWONUS Kishinouye, 1915

Katsuwonus Kishinouye, 1915, *Sui. Gak. Ho*, 1, p. 21. Orthotype, *Scomber pelamis* Linné.

Katsuwonus pelamis (Linné, 1758).

Scomber pelamis Linné, 1758, *Syst. Nat.*, ed. 10, p. 297. Type locality: In pelago inter Tropicos.

Example in Tamar River. Though not included in any published Tasmanian list, *Katsuwonus pelamis* is well-known in our waters (Munro 1957 ; Scott 1962), which it visits in schools in late summer and early autumn (Robins 1952): in a schedule of fisheries for 1972-73 (Anon. 1974) Tasmania is shown as having provided 40 tonnes of the Australian total of 111 tonnes. However, it is usually taken in deep water off our East Coast. An example, *Ls* 482, *Lt* 546, caught on 10 May 1974, during the Apex Fishing Competition, in the Tamar river, between Gravelly Beach and the river mouth, provided an unusual (indeed, within the knowledge of local professional fishermen consulted, an unprecedented) record for the locality.

The specimen is also noteworthy in wholly lacking the characteristic accessory keels on the caudal peduncle.

Meristic characters. D.XV,16;8 finlets. A.14;7 finlets. P.26/26.V.I,5. C.12+12. Gill rakers on lower limb of anterior arch 37.

Principal proportions as *Tls*. Length to end of upper caudal lobe 1144, to end of lower lobe 1133, to end of middle caudal rays 1050. Length to origin, termination of first

dorsal 353, 604; of second dorsal 658, 725; of anal 701, 778. Length to vent (middle) 673. Length to origin of pectoral 303, length of fin 156. Length to origin of ventral 313, length of fin 118. Length to origin of upper caudal lobe 979, to lower caudal lobe 981; to caudal keel 1050, length of keel 15, height of keel 29; spread of caudal 249. Head 293; snout 54; eye 43 (horizontal diameter), 46 (vertical diameter); interorbital 29. Oblique length of upper jaw 116. Greatest width of maxilla 20, end of maxilla to eye 23. Depth (in parentheses, width) at front of eyes 114 (83), back of eyes 147 (108), operculum 239 (160), first dorsal origin 249 (182), vent 239 (145); maximum 268 (199); caudal peduncle 24 (29). Length of first dorsal ray 81, last 15, longest (4th) 83; first anal ray 74, last 7, longest (3rd) 80. Ventral spine, left 98, right 95. Lengths of dorsal spines and pelvic rays are recorded below in the section on fin patterns.

Other features. Head, trunk, tail 29.5, 38.9, 31.5%, respectively of standard length. Body-form: mesosomatic, gasterion preapical, apex median, gasterion median, mesonotic, mesogastric, leptopygidial, opisthion preuranic (Gregory 1928).

Maxillary extending to level of front of pupil, or 0.3 eye. Opercular membrane minutely crenulated. Teeth in jaws small, uniserial, well separated; an edentulous median space, about half eye. Pectoral reaching to below dorsal spines IX-X, ventral to below spine VII. Lateral line in part wavy, most noticeably under second dorsal, there briefly sigmoid: beyond caudal keel 15 minute projections in about 7 mm, apparently a continuation of lateral line. Corselet extending at its main backward angle behind head by four-fifths head, a superior spur continuing along lateral line by a further one-tenth head, continuous with a line of one or two scales bordering lateral line throughout most of its length; a further backward extension flanking either side of the first dorsal and most of the second. Scales of corselet decreasing regularly in height caudad from about two-fifths of an eye diameter to about one-twentieth as much. Operculum naked save for a few scales along its upper border; an elliptical naked patch at angle of preoperculum; rest of cheek scaled below a smooth pennon running back, mostly on dorsum, from near upper orbital rim to within about one and a half eye diameters of dorsal origin, scales, many large, polygonal or longitudinally subelliptical, extending down from this to inferior border of preoperculum, and continuing forward below eye to level of end of gape. Main ventral keel well developed (dimensions above); no accessory keels. Dorsal wholly retractable into a slot, from which a pull on the anterior spine brings it out like a half-opened fan. Anal set on a subelliptical escutcheon, its minor (transverse) axis one-third its major axis, or about two-thirds eye. A similar, slightly wider, but less conspicuous elevated area surrounding base of second dorsal.

Coloration. General color bluish silvery above lateral line, chiefly silvery below it. Five well-marked dark stripes on flank below lateral line, the longest extending from shortly behind pectoral almost to caudal peduncle; widest above anal base, width of lower two here subequal to interval between them, others wider than their interspaces. Larger scales on trunk usually outlined in, smaller usually spotted with, dirty white. Large scales on cheek dark grey, outlined in greenish gold or whitish. Small black spot at upper end of opercular border. Internal surface of pectoral base with one (right side) or two (left) black arcs; both fins with subelliptical blackish spot at base of upper rays. Dorsal spines mainly slaty with some darker patches; membrane greyish, with, from about 6th interval backward, increasing blackish smudging, most pronounced distally. Second dorsal tolerably even grey; some small patches, approaching black, at tips of first few rays. Anal grey. Dorsal and anal finlets slaty, with whitish border, wider, more sharply delimited in anal. Pectoral greyish. Ventral somewhat yellowish grey, some duskiness in preaxial half or so. Caudal mainly greyish with some dusky clouding, hind border briefly almost white.

Remarks. Surprisingly, the specimen presents no indications of the presence of the characteristic smaller keels normally found (Munro 1958b, p. 114) above and below the

primary keel on either side of the caudal peduncle. In general form and color pattern it agrees closely with the figure by Serventy (1941, pl. 3, fig. 2). The Handbook notes two proportions only: these (with our values in parentheses) are depth 3.7-3.8 (3.74), head 3.1-3.4 (3.40) in length without caudal.

Disposition of finlets. The 8 dorsal and 7 anal (ventral) finlets are divisible in respect of their relative locations, into an anterior subset of 3 in either fin and a posterior subset of 5 (dorsal), 4 (anal). With distance from tip of snout to first finlet measured between parallels, and with intervals between finlets measured directly with callipers, the following relations are found (L= length to finlet origin, N= serial number of finlet, counting caudad). For dorsal finlets 1-3 the best straight line is log L=0.1000 log N+2.5600 (t=9.022), giving measured (predicted) lengths, mm, 364.0 (363.5), 386.5 (385.1), 407.0 (405.2); for anal 1-3 log L=0.07544 log N+2.5869 (t=9.409), with lengths 387.0 (386.3), 405.0 (407.0), 421.0 (419.7). For dorsal finlets 4-8 log L=0.1625 log N+2.5262 (t=40.505), with lengths 421.4 (420.7), 435.5 (436.2), 448.6 (449.6), 461.4 (460.8), 471.7 (470.9); for anal 4-7 log L=0.1519 log N+2.5445 (t=24.681), with lengths 436.0 (437.2), 450.5 (447.4), 465.0 (460.0), 474.0 (470.9).

Fin patterns. In species, belonging to various families, so far examined the most common type of dorsal fin presents an anterior suite of spines increasing in length caudad, followed by a (usually longer) suite decreasing in length caudad — the latter not infrequently resolvable into two or more components, the graphs of which, with log length plotted against log inverse serial number (*i.e.*, spines counted cephalad), exhibit a positive slope. Here the fin not only represents a less common type in that the most anterior spine is the longest, but it presents a further unusual feature, the plotting of log length against log serial number (direct or inverse as appropriate) yielding linear graphs for three subsets as follows: (*a*) on serial numbers 1, 2, 3 spines III, II, I (slope positive); (*b*) on serial numbers 1, 2, 3 spines IV, V, VI (slope negative); (*c*) on serial numbers 1-9 spines XV-VII [spine IX on 7 omitted; imperfect] (slope positive) — subset (*b*) thus being of an exceptional character. Specifications of these three subsets are as follows: (*a*) log L=0.2099 log N+1.7877; measured (predicted) lengths, mm 61.3 (61.3), 71.0 (70.9), 77.2 (77.2); t=19.834: (*b*) log L=−0.7547 log N+0.6552; 44.9 (45.2), 27.3 (26.8), 19.5 (19.7); t=25.164: (*c*) log L=0.2353 log N+0.9130; 8.0 (8.2), 10.0 (9.6), 11.0 (11.3), 12.0 (12.0), 12.1 (12.5), — (—), 13.3 (13.4), 14.0 (14.7); t=17.341 (with more material available for examination, it is possible (*c*) might be divisible into anterior and posterior sections).

Equations of the form $L=bN^k$, here presented as log $L=k$ log N + log b, are noted below for pectoral rays 1-4. For left fin k is 0.7150, for right 0.7401; log b for left 1.2650, for right 1.2367; significance, left t=43.256, right t=17.216; measured (calculated) lengths, mm, left 18.4 (18.4), 30.0 (30.2), 41.2 (40.4), 49.0 (49.6), right 17.4 (17.2), 28.1 (28.8), 39.3 (38.9), 48.4 (48.1). No simple and obvious relationship between on the one hand the subset of rays 1-4 and on the other hand ray 5 and spine is apparent. However, when log lengths of ray 1, spine, ray 5 are plotted on logs, 1, 5, 6, respectively, a virtually linear graph results — a formulation perhaps, however, without systematic significance. For left ventral log L=0.5925 log N+1.2642; lengths 18.4 (18.4), 47.0 (47.7), 53.8 (53.1); t=136.39: for right log L=0.6084 log N+1.2410; 17.4 (17.4), 46.0 (46.4), 52.3 (51.8); t=12.988.

Family BOTHIDAE

Tasmanian members of the family listed in the Handbook (Munro 1957b) comprise (*a*) *Lophonectes gallus* Gunther, 1860, (*b*) *Arnoglossus muelleri* (Klunzinger, 1872), (*c*) *A. bassensis* Norman, 1926, (*d*) *A. andrewsi* Kurth, 1954 (endemic), (*e*) *Pseudorhombus tenuirastrum* (Waite, 1899), (*f*) *P. jenynsii* (Bleeker, 1855). None of these appear in either of the local lists of Johnston (1883, 1891). Lord (1923, 1927) and Lord & Scott (1924) list (*a*) and (*e*), together with (*g*), *Pseudorhombus multimaculatus* Gunther; while the Australian Checklist (McCulloch 1929) records as Tasmanian (*a*), (*b*), (*c*), (*d*), accept-

ing (*g*) as a valid species, but not accrediting it to this State. Norman, having treated the Small-toothed Flounder under Gunther's name, (*g*), in his report on the *Endeavour* Heterosomata, later in his monograph (1934) referred it to the synonymy of (*f*), a course in which he is followed by Munro in the Handbook.

A new species of *Arnoglossus* Bleeker, 1862 is here described and figured, and some observations are made on two examples, a male and a female, of *Lophonectes gallus*. A key to the Tasmanian species is subjoined.

Genus *LOPHONECTES* Günther, 1880

Lophonectes Günther, 1880, *Rept Challenger, Zool.*, 1(6), p. 28. Haplotype, *Lophonectes gallus* Gunther.

Lophorhombus Macleay, 1883, *Proc. Linn. Soc. N.S.W.*, 7(1), p. 14. Haplotype, *Lophorhombus cristatus* Macleay = *Lophonectes gallus* Gunther.

Lophonectes gallus Günther, 1880

Lophonectes gallus Günther, 1880, *Rept Challenger, Zool.*, 1(6), p. 29, pl. XV, fig. B. Type locality: off Port Jackson; 30 fms.

Laeops parviceps Gunther, 1880, *Rept Challenger, Zool.*, 1(6), p. 29; *partim* (2 *Challenger* specimens, off Twofold Bay, N.S.W., 120 fms = young).

Lophorhombus cristatus Macleay, *Proc. Linn. Soc. N.S.W.*, 7(1), p. 14. Type locality: Port Jackson.

Distribution. All Australian States except Western Australia; also, if *L. monoguiensis* Regan, 1914 is conspecific [so regarded by Norman (1934, p. 202), but accorded specific status by Whitley (1968, p. 47)], New Zealand. It does not appear in either of the Tasmanian lists of Johnston (1883, 1891), while in those of Lord (1923, p. 65; 1927, p. 13) and Lord & Scott (1924, p. 47) the entry is merely the name, unaccompanied by locality records or other data. Some observations are here made on two specimens, (*a*) female, *Ls* 116, *Lt* 142, (*b*) male, *Ls* 119, *Lt* 145, collected 24 August 1973 off Prime Seal Island, Furneaux Group, Bass Strait by Mr P. Armstrong; Q.V.M. Reg. No. 1974/5/53.

General features. In the subjoined description features are noted in the same order as in the description in Norman's monograph (1934, p. 202, fig. 150) based on 28 examples from New South Wales, Bass Strait, and off the northern island of New Zealand, quantitative data reported by him being here cited in parentheses: however, some additional items are intercalated at appropriate points. Where a datum is reported twice the first entry relates to the smaller individual (female).

Depth 2.6 (about 2½), depth at front of eyes 7.0, 6.8, at back of eyes 3.7, 4.2, at operculum 3.0, 3.3; depth of caudal peduncle 9.8, 9.3 in *Ls*. Head 4.5, 4.5 (4¼-5 1/5) in *Ls*. Snout 1.2, 1.3 in lower eye, 1.3, 1.3 in upper eye (shorter than eye). Eye, lower, 3.8, 3.5, upper 3.8, 3.3 (3¼-4) in head. Eyes separated by a narrow bony ridge, lower 0.3, 0.2 its own diameter, (very slightly) in advance of upper, which is separated from edge of head by a space equal to 0.4, 0.4 (1/5-½) its diameter. Interorbital 7.1, 8.0 in diameter of lower eye, direct distance between middle of upper border of upper eye and middle of lower border of lower eye 1.6, 1.4 diameter of lower eye. Maxillary extending to below middle of elevated fleshy orbital rim, short of rim by width of rim (below anterior edge or a little beyond); its length 3.8, 3.8 (3 1/3-nearly 4) in head; lower jaw 2.2, 2.2 (2¼-2 2/3) in head. Both nasal organs on ocular side, the larger more advanced one lying on horizontal level of interorbital, its distance from mouth cleft subequal to its height, or about half its distance from lower eye, which is a little less than its distance from upper eye; whitish, unpigmented save for very brief basal peppering of minute brownish chromatophores; elliptical in plan, set obliquely, erect; pentagonal posterior wall three or four times as high as anterior

KEY TO BOTHIDAE RECORDED FROM TASMANIA

1. Lateral line on both sides; that on ocular side extending in advance of upper end of operculum in an upward supra-temporal branch reaching to dorsal base, and in a downward branch behind eyes. Bases of left and right ventrals subequal; subequal to anal-ventral interspace. D. 84 (≐ 67-80). A.<68(≐ 51-63).....2

   Lateral line on ocular side only; terminating close to upper end of operculum. Base of left ventral much longer than base of right; greater than anal-ventral interspace. D. 84(≐ 87-99). A.>68(≐ 71-78).....3

2. Scales ctenoid on ocular side, cycloid on blind side. Gill rakers on lower part of anterior arch 6-10. Head 3 2/5-4 (nearly) in *Ls*. D. 67-74. Markings include 5 ocelli, in 2 pairs, one member of each pair above the other, and a (posterior) azygous ocellus (exceptionally, a 6th may occur behind this).....*Pseudorhombus jenynsii*

   Scales cycloid on both sides (those on ocular side often with rough or spiny patch well within hind margin of scale). Gill rakers on lower part of anterior arch 11-13. Head 4-4½ in *Ls*. D. 74-80. Markings include 6 ocelli, in 3 pairs, one member of each pair above the other.....*Pseudorhombus tenuirastrum*

3. Some anterior dorsal rays produced. Maxillary 3¼-4 in head. Male with bony tubercles on snout and near mandibular symphysis; these smaller, blunter, occasionally absent, in female.....*Lophonectes gallus*

   No dorsal rays produced. Maxillary 2-3 in head. No bony tubercles on snout or near mandibular symphysis.....4

4. Gill rakers pointed, simple.....5

   Gill rakers blunt, spinulate (palmate).....6

5. Scales ctenoid (feebly) on ocular side, cycloid on blind side. Lateral line scales<80(≐68-73). A.72-75. Body uniform brown.....*Arnoglossus muelleri*

   Scales cycloid on both sides. Lateral line scales>80 (≐87-92). A.77-78. Body greyish brown, with dark blotches and spots, including two large black blotches on lateral line.....*Arnoglossus bassensis*

6. Anterior dorsal profile normally rounded, reaching apex about a head length behind head, then descending evenly to caudal peduncle. Both sides of dorsal and anal rays scaled. Left P.10. D.90-94. Caudal rounded.....*Arnoglossus andrewsi*

   Anterior dorsal profile rising steeply, reaching apex about above opercular border, then continuing backward virtually horizontally for about one and a half head lengths before descending evenly to caudal peduncle. Only ocular side of dorsal and anal rays scaled. Left P.12. D.98. Caudal obtusely pointed.....*Arnoglossus armstrongi*

tubular wall, which is lowest mesially, curving up laterally to meet elevated hind wall; two digitiform processes, one higher, arising from middle of posterior wall, one from middle of anterior wall; nasal laminae apparently with a central rachis: the hinder organ contiguous basally with the front one, behind and partly below it; concolorous with snout nearby; a rounded or slightly elliptical mound, lower wall steeper than upper; a terminal crescentic opening, its long axis sloping about equally downward and forward. Margins of operculum and preoperculum entire; free hinder border of preoperculum extending up to level of lower half, just above middle, of pectoral base. In both specimens two largish ocular and several rudimentary rostral tubercles on ocular side, one large complex one just behind mandibular symphysis; bony, enveloped, except, usually, at tip, in thick integument.

Teeth present on both sides, perhaps a little better developed on blind side, small, slender, uniserial, those in front half of jaw somewhat larger than those behind them (teeth small, scarcely enlarged anteriorly). Gill rakers moderate, longest about half longest gill filament, 6 on lower limb of anterior arch, increasing in height and width from 1st (uppermost) to 4th, with 5th, 6th lower, wider, subequal; earlier about twice, later about one and one-third as high as wide (short or of moderate length, rather stout; 6 or 7 on lower part of anterior arch). Scales on ocular side ctenoid, modally with 20-22 slender, acuminate spinules, their length from once to about twice, modally about one and a half, their interspaces (ctenoid): on blind side cycloid, exposed margin evenly rounded or somewhat sinuate (cycloid). Scales on lateral line 67 [2 on caudal], 69 [4 on caudal] (62-70). General course of lateral line much as in Norman's illustration (fig. 50) with the following modifications: female, short anterior segment longer, with about 6 tubules, descending almost to operculum, with a terminal upwardly concave portion of 2 tubules; male, anterior segment of 5 descending at a lesser angle, with the first tubule not far from horizontal, and at junction of its 2 uppermost tubules what appears to be an abnormal accessory branch running backwards and downwards over 2 scales, then bifurcating and continuing for rather more than another scale. Width of curved portion of lateral line, measured horizontally at lower end of subvertical portion of anterior segment [*i.e.*, 3 tubules down this line in (*a*), 1 tubule in (*b*)] 2.7, 2.4 in head. Lateral line not developed on blind side.

Dorsal 88, 88 (87-93) rays simple; in (*a*), female, 1st-7th rays 0.23, 1.27, 1.20, 1.06, 0.42, 0.42, 0.42 head (only the third to fourth or fifth rays prolonged in the female, length ½ to 9/10 that of head); in (*b*), male, 1st-7th rays 0.23, 1.28, 1.08, 1.35, 1.26, 0.72, 0.42 head (second (occasionally first) to fifth, sixth or seventh rays much prolonged in the male (except in very young), longest rays (in adults) 1½ to about twice length of head); in (*a*) last ray 0.08, ray at middle of fin 0.44 head, in (*b*) 0.08, 0.46: ocular side of rays with minute, deeply embedded scales along most of their length, the best developed with about 10-12; blind side of rays without scales. Anal 70, 75 (71-77), rays simple; 1st ray 4.0 —[imperfect], 2nd 3.3, 3.3, ray at middle of fin 2.3, 2.2, last ray 2.7, 2.4 in head; ocular side of rays with up to a score of minute deeply embedded scales along most of their length. Pectoral of ocular side 12, 12 (11-12), rays simple, length, whole fin, 0.8, 0.8, longest [3rd, 3rd = 4th] ray 0.7, 0.7 head (pectoral length 2/3-3/4 head). Pectoral of blind side, 11, 11, rays simple, about two-thirds size of that of ocular side, length, whole fin, 0.6, 0.5, longest ray [5th, 4th = 5th] 0.5, 0.4 head. Left ventral 6, 7 [7th, posterior, rudimentary], rays simple, longest ray [3rd, 3rd] 0.4, 0.4 base, measured from ray to ray, 0.3, 0.4, or, including posterior membrane 0.4, 0.4 head; adpressed, fin reaches just short of level of posterior angle of operculum, below origin of pectoral base, anterior portion of base extending somewhat in advance of lower angle of operculum, set on, or virtually on, midventral line, posterior portion swinging slightly on to left flank. Right ventral 6, 6, rays simple, longest ray [4th, 4th] 0.3, 0.3 head, base less than half that of left ventral [0.2, 0.1 head], originating about opposite middle of right base, terminating briefly before it, lacking posterior attachment membrane, wholly off midventral line, set somewhat obliquely, posterior end about twice as far from median line as anterior end. Caudal 17, 18, with 11, 10 rays divided, pointed in male, rather

more rounded in female, longest ray 1.0, 1.1 in head; scales extending well up rays on ocular side, confined to about basal one-seventh on blind side; some small hairlike processes on proximal half of rays on ocular side.

General color, after preservation, of ocular side somewhat brownish grey, appearing yellowish where scales have been lost; of blind side more or less uniform pale yellowish, except for some pale orange in an ill-defined patch on head, and in strips along dorsal and ventral profiles demarcating location of pterygiophores; no obvious discrete markings on either side. Dorsal and anal rays greyish, mostly with small brownish dots, spaced like the scales; membranes pale grey. Pectoral of ocular side grey; in (*b*) a regular arc of small brown spots between bases of rays, indications of two or three further irregular arcs in proximal one-third of fin; in (*a*) spots fewer, more irregularly disposed; in both specimens some similar spots on fin base. Pectoral of blind side white. Ventral of ocular side with anterior rays and membrane between them wholly or mostly white or whitish, other rays conspicuously dusky, in part almost black, tips of rays white. Ventral of blind side white. Caudal more or less colorless, rays a little dusky distally in female.

Remarks. From the above comparative account it can be seen our specimens agree closely with Norman's description, with fin counts and body proportions falling in all cases but one — length of lower jaw 2.2, 2.2 (*cf.* 2¼-2 2/3) in head — within the ranges noted by him. Perhaps the most noteworthy differences are the more pointed caudal in the male in our material, and the presence (probably abnormal and individual) in the same fish of an accessory branch arising from near the anterior end of the lateral line.

Lophonectes gallus appears to provide yet another example of a species found in New South Wales [also, in this instance, in Queensland (Marshall 1964)] occurring in Tasmania without appearing in South Australia (or ? Victoria).

In his report on the *Thetis* expedition — which found this species the commonest flatfish secured — Waite (1899, p. 124) called attention to the comment by Ogilby (1886, p. 48) on Gunther's (1880) original figure, based on *Challenger* material, 'In Dr. Gunther's figure the fish is coloured on the wrong side, the short first dorsal ray is omitted, and there is a separation between the elongated and short rays of that fin which is purely imaginary.'

Additional material. Since the above observations were made, an additional example has come to hand, this time from the other (western) side of the north coast region, a male, *Ls* 119.0, *Lt* 143.0, dredged in Ringarooma Bay by Mr J. Shea on 19 September 1974; Q.V.M. Reg. No. 1974/5/167.

D. 88. A. 76. P., ocular side 12, its length 1.6; blind side 10, its length 1.8 in head. Both ventrals 6; longest ray of left (4th) 2.24, of right (4th) 3.2 in head; base of left 2.7, of right 5.4 in head. C. 3+11+3. Depth 2.7, head 4.4 in *Ls*. Snout 1.2 in upper, 1.3 in lower eye, latter 3.9 in head (all eyeball measurements), or 1.9, 1.7, 2.9 (total eye). Maxilla to front of eye; lower eye in advance of upper by almost one-third diameter of its eyeball ('slightly', Norman 1934). Maxilla 4.0, lower jaw 2.3 in head. Produced dorsal rays 2nd, 3rd (longest 1.18 head), 4th, 5th. Dorsal 1st, middle, last rays 4.4, 2.1, 9.3 in head; anal 3.1, 2.3, 13.6 in head. Depth of caudal peduncle 2.17 in head. Characteristic dark distal marking on left ventral, involving rays 3-6, darkest, almost black on 3rd ray.

Genus *ARNOGLOSSUS* Bleeker, 1862

Arnoglossus Bleeker, 1862, *Versl. Med. K. Akad. Wet. Amsterdam*, 13, p. 427. Tautotype, *Pleuronectes arnoglossus* Bloch & Schneider.

Arnoglossus Norman, 1934, *Monogr. Flatfishes (Heterosomata)*, 1, *Psettodidae, Bothidae, Pleuronectidae*, p. 173 (synonymy).

Arnoglossus armstrongi sp. nov.

(fig. 2)

Diagnosis. Anterior dorsal profile rising very steeply, reaching its virtual apex about above opercular border, then continuing back almost horizontally for about one and a half head lengths. Depth 2.2, head 3.8 in length without caudal. Barely notched in front of eyes, but decidedly concave here. Scales ctenoid on ocular side, cycloid on blind side. D.98. A.74; rays with scales on ocular, not on blind side. P.12/12. Lateral line on left side only; curved over pectoral, no supratemporal branch. Gill rakers low, broad, partly spinulate ('palmate').

Size. Standard length, *Ls*, 168.5, total length, *Lt*, 198.5.

Meristic characters. D.98. A.74. V.6/6. P.12/12. C.17 (3 upper, 2, ?3, lower, rays simple). Lateral line tubules 91 (22 in anterior curved segment, 58 in horizontal segment to hypural, 11, becoming progressively smaller, on caudal).

Principal dimensions. Measurements are given as *Tls*, with absolute dimensions, mm, in parentheses. Head 261 (43.9). Snout to orbit 53 (9.0), to eyeball 58 (9.8). Upper eye, eyeball 53 (9.0), total 62 (10.5); lower eye, eyeball 51 (8.6), total 64 (10.7). Interorbital 7.1 (1.2). Length of maxilla 100 (169), of lower jaw 131 (22.0). Length to vent (middle) 236 (39.7), diameter of vent 21 (3.6). Depth at front of eyes 154 (26.0), back of eyes 249 (42.0), vent 374 (63.0), opercular border 389 (65.5); maximum depth 416 (70.0); depth of caudal peduncle 107 (18.1). Lengths of dorsal rays, 1st 53 (9.0), middle 118 (19.8), last 18 (3.0); of anal rays, 1st 62 (10.4), middle 125 (21.0), last 12 (2.0). Left pectoral, length 137 (23.0), longest (3rd = 4th) ray 127 (21.4), oblique length of base 35 (5.8): right pectoral, length 119 (20.1), longest (6th) ray 118 (19.8), oblique length of base 21 (3.5). Left ventral, base 77 (12.9), longest (5th) ray 65 (11.0): right ventral, base 41 (6.9), longest (3rd) ray 48 (8.1).

General description. Dorsal profile fairly evenly rounded from mouth cleft to level of middle of eye, barely notched; excavated in front of rest of eye and for about half an eye diameter above it; thereafter rising in a compound segment with chord about equal to head without eye, to reach within a millemetre or two of greatest height of whole dorsal profile at level of opercular margin, this segment with its anterior half almost straight, at approximately 40° to horizontal, the rest moderately convex; behind operculum profile nearly straight (height of chord about one-third eye) to 0.7 *Ls*, or behind head by 1.6 head; thence in one gently sigmoid sweep, its general sense approximately 30° to horizontal, to caudal base. In ventral profile lower jaw straight; a slight spur at its junction with moderately rounded operculum; thence one convex sweep, with increasingly rapid curvature caudad, to caudal base; lowest point behind head by about two-thirds head. Depth at front of eyes 6.5, behind eyes 4.0, at vent 2.7, at opercular border 2.6; maximum depth, found at one-third of length, 2.4; depth of caudal peduncle 9.3 in *Ls*.

Head 3.84 in *Ls*. Snout a little shorter than full eye; measured to orbit, equal to upper eyeball, 1.05 lower. Lower eye in advance of upper eye by about one-sixth diameter of latter; lower closer to maxilla than upper to dorsal profile. Upper eye, full, eyeball 4.2, 4.9 in head; lower 4.1, 5.1: separated by a narrow bony interorbital, on to the posterior one-third of which closely-set scales extend, the rest naked; from scales the median ridge on which they are set continues forward as a well-elevated, translucent, somewhat porcelain-like bar, following the curve of the lower eye, and constituting, in effect, its supraorbital ridge, its distance from the other eye thus being greater at its ends (especially the anterior) than at its middle; least width of interorbital about one-seventh diameter of lower eyeball. Maxilla extending to below 0.3 lower orbit; hind margin obliquely truncate, with lower, rounded angle projecting behind upper; length 2.6 in head, or 4.2 its greatest width measured normal to its main axis. Lower jaw 2.0 in head: with mouth closed, lower lip slightly in advance of upper;

a small tubercle near mandibular symphysis a little further advanced. Teeth at back of jaw minute, at front usually large, stout, more or less strongly recurved; bulk of largest greater than that of smallest by a factor probably exceeding fifty; on left side 8 in upper jaw (3 large, 1 medium), 9 in lower jaw (3 large, 2 medium); on right side 15 in upper jaw (5 medium-small), 10 in lower jaw; in general uniserial, but a couple of pairs; characteristically, well, or fairly well, separated, but one set of 4 small set very close together; some of the larger teeth apparently depressible. Gill rakers on lower limb of hinder arch 6, 'palmate' (*i.e.*,short broad, margins spinulate; Norman), variable in form; 1st (uppermost) a digitiform process, sloping slightly downwards, spinulate at tip and on upper border; 2nd a smaller, more rounded, more sloping process, delicately crenulate distally; 3rd subtriangular, similarly crenulate; 4th and 5th with longer bases, more rounded, somewhat more boldly crenulate (especially 4th); 6th little more than a low crenulated ridge, its length about one and one-third that of 5th, about 4-5 times its own height. On lower limb of anterior arch 5 (?) rakers, apparently more or less similar to, but less developed than, those on hind arch. A small set of long acute pharyngeal spines. Lateral line comprises (*a*) a principal midlateral segment of 58 tubules curving upward from middle of caudal peduncle to a point behind head by about combined eye and snout, 1.4 times as far from ventral as from dorsal profile, overlapped here by distal one-fourth of adpressed pectoral, the curve roughly divisible into two sections, anterior about twice as long as posterior, height of overall curve about half an eye diameter; (*b*) anterior segment curving over pectoral, in region of nape, made up, proceeding cephalad, of an upward and forward series of 5 tubules, a longitudinal series, moderately curved upwards, of 9, a downward and forward series of 5 with a forward more or less horizontal spur of 3, ending shortly above, just in advance of, upper angle of operculum, width of curved portion, without spur, 1.3 in head; (*c*) a series of 11 tubules on caudal, becoming progressively smaller, only first 2 or 3 comparable in size with those on flank.

Vent on blind side above base of 1st anal ray; length to middle 4.22 in *Ls*, or 0.90 head.

Dorsal with 98 rays, none prolonged, all simple; scaled on ocular, not on blind side; 1st ray inserted on blind side (and exhibiting its coloration, white; *cf.* other rays, dark grey), insertion behind snout profile by about half its distance from upper lip, or one-third length of ray, which is 4.9 in head; middle rays 2.2 in head; last ray briefly in advance of 1st caudal ray, 14.5 in head. Anal with 74 rays, all simple; scaled on ocular, not on blind side; lengths of 1st, middle, last rays 4.2, 2.1, 22.0 in head; last ray inserted in advance of caudal by about its own length. Both ventrals with 6 simple rays; base of left 1.9 that of right, or 3.4 in head; longest ray of left 1.4 that of right, or 4.0 in head. Both pectorals with 12 simple rays; left 1.1 length of right, or 1.9 in head, its base 1.7 base of right, or 7.5 in head. Caudal with 17 rays, of which 3 upper and 2, ?3, lower are simple; obtusely pointed.

Coloration. In its present state, after preservation, the greater part of the ocular side of the fish has an almost uniform pale yellowish ground color; each scale pocket (most scales lost) outlined in blackish, resulting in an overall dark lattice. Some areas with ground color a little dusky include ovoid abdominal region, a longitudinal strip a little more than an eye diameter in width extending subparallel to ventral profile from end of abdomen to within about a head length of hypural, its distance from profile subequal to its width, an indefinite narrow dusky strip along most of dorsal profile, a slight and obscure mesial darkening on flank in posterior one-fourth of length, and much of snout. The only conspicuous marking is a short upright irregular blackish bar lying across lateral line at end of second third of length of its main segment, its width about half its height, latter rather more than an eye diameter. Blind side virtually uniform pale yellowish, devoid of any noticeable marking.

Ocular side of dorsal rays ranging from light to dark grey, most with a more or less well developed series of up to a dozen darker spots or patches indicative of

position of scales; blind side of rays chiefly whitish or very pale greyish, some showing slight distal duskiness; first ray wholly white. Anal rays in general similar to dorsal; some anterior ones more distinctly white on right side. Left pectoral dark brownish, with some short blackish bars, several forming an arc; right wholly white. Rays of left ventral like those of left side of anal rays; of right ventral white.

Material. Described and figured (fig. 2) from the unique holotype, standard length 168.5 mm, total length 198.5, collected at Bridport, northern Tasmania, on 15 August 1973 by Mr Philip Armstrong, in whose honour the species is named; deposited in the Queen Victoria Museum, Launceston; Reg. No. Q.V.M. 1974/5/168.

The specimen is not in a particularly good state of preservation, apparently having been subject at some stage to desiccation that has led to loss of most of membrane of vertical fins and to marked brittleness in most of their rays. It is not feasible to determine with certainty throughout the full lengths of dorsal and anal just how far up the rays the membrane originally extended (a point not without taxonomic significance: contrast, for example, the short membrane between early dorsal rays in *A. bassensis* with the almost full-length membrane in *A. andrewsi*). There are some indications that suggest the early dorsal membrane may here not have extended to near the tip of the ray.

Affinities. The holotype differs at sight in general form from all described species of *Arnoglossus* (to which genus, however, it appears clearly to belong), the long section of virtually straight upper profile behind head being somewhat suggestive of a dextral soleid. As only a single example is available, the possibility that this unusual shape is an individual variation cannot wholly be ruled out: however, additional diagnostic features serve adequately to characterize the species. Of the nine species of *Arnoglossus* Bleeker, 1862 appearing in the Handbook (Munro 1957b) four have scales of both sides cycloid, and hence call for no consideration here. From the remaining species [including *A. tenuis* Gunther, 1880, for which no characterization of scales is noted in the Handbook, but which has scales on ocular side feebly ctenoid (Norman 1934, p. 188)] the present form is distinguishable as below.

From *A. bleekeri* Macleay, 1882 (referred, somwhat provisionally, by Norman to *Engyprosopon* Gunther, 1862 on dentition) by that species' dentition (partly biserial), interorbital (groove), gill rakers (not palmate), fewer dorsal rays (90-93), fewer lateral line scales (50), smaller head (4.2-4.5 in *Ls*), shape of caudal (rounded), color pattern (spot on operculum).

From *A. muelleri* (Klunzinger,1872) by that species' gill rakers (not palmate), more numerous lateral line scales (68-73, *i.e.*, from near angle of gill opening to caudal base), fewer pectoral rays (10), smaller head (4-4.5 in *Ls*), shape of caudal (rounded), probably color pattern (fins with small brown spots).

From *A. intermedius* (Bleeker,1866) by that species' interorbital (groove), fewer dorsal rays (77-82), fewer anal rays (57-62), fewer lateral line scales (43-46), shape of caudal (rhomboidal), color pattern (dark blotches and annular markings on body, all fins with numerous dark spots).

From *A. tenuis* Gunther,1880 by that species' dentition (teeth all small), gill rakers (not palmate), fewer dorsal rays (90-93), fewer anal rays (70), fewer lateral line scales (48), possibly smaller head [given by Norman (1934, p. 187) as 4-4.5; in Handbook, apparently in error, 2.75].

From *A. andrewsi* Kurth,1954 by that species' fewer dorsal rays (90-94) fewer pectoral rays (10), scalation on dorsal and anal rays (on both ocular and blind sides of both fins), possibly by smaller head [Kurth (1954, p. 46), noting head in *Ls* for holotype as 4.2, gives range as 2.4-4.4 (figures repeated in Handbook): a figure of 2.4

would seem to indicate an improbably large head: for five species with head in *Ls* about 4 the ranges given in Handbook lie between 0.25 and 0.5: possibly 2.4 is misprint for 4.2].

Of the five species just noted only two *A. muelleri* and *A. andrewsi* are recorded from Tasmania (latter endemic), the others being Queensland forms. On the whole, the present species comes closest to *A. andrewsi*, with which it shares the unusual possession of palmate gill rakers. The character would appear to be an important one. Of 24 species of *Arnoglossus* recognised by him, Norman observes (1934, p. 198) of *A. intermedius*, 'This species is provisionally placed here, but perhaps represents a distinct genus. It may be distinguished from all species of *Arnoglossus* by the form of the gill-rakers [palmate], which are similar to those of certain species of *Pseudorhombus*, and from most of them by the concave interorbital space'; and in his synopsis of 24 species of *Pseudorhombus* he keys off those 3 species — *P. spinosus* McCulloch, 1914, *P. diplosus* Norman, 1926, *P. dupliciocellatus* Regan, 1905 (all reported from Australia) — that have the gill rakers short, broad, spinulate.

Family SOLEIDAE

Of the two families of soles that have generally been recognised, and that are accepted by Greenwood *et al.*, the dextral soles, or true soles, Soleidae, and the sinistral soles, Cynoglossidae, with, respectively, 27, 11 Australian species (Munro 1957c, d), the former has hitherto been without known Tasmanian representatives, while the latter provides one entry in the local list, *Paraplagusia unicolor* (Macleay, 1881). The second family noted above is subsumed in the first by Weber & de Beaufort (1929), while the Australian Checklist (McCulloch 1929) separates off from the second family, a third, Synapturidae.

Two examples of *Zebrias fasciata* (Macleay, 1882) are here reported from our waters.

Genus *ZEBRIAS* Jordan & Snyder, 1890

Zebrias Jordan & Snyder, 1890, *Proc. U.S. Nat. Mus.*, 23, p. 38. Orthotype, *Solea zebrias* Temminck & Schlegel.

Zebrias fasciata (Macleay, 1882)

Synaptura fasciata Macleay, 1882, *Proc. Linn. Soc. N.S.W.*, 7(1), p. 14. Type locality: Port Jackson.

Synaptura fasciata Waite, 1899, *Mem. Aust. Mus.*, 4(1), pl. XXXI. *Id.* McCulloch, 1916, *Mem. Qld Mus.*, 5, p. 61, pl. VIII, fig. 2. *Id.* McCulloch, 1929, *Mem. Aust. Mus.*, 5(2), p. 285.

Brachirus fasciatus Norman, 1926, *Biol. Res. Endeavour*, 5(5), p. 295.

Zebrias fasciatus Munro, 1957, *Handbk Aust. Fish.*, 17, p. 71, fig. 494.

Record. Two examples collected by Mr P. Armstrong, (*a*) *Ls* 131, *Lt* 149, between East Sandy Cape and Thirty Day Island, 1973 (received 9 August), Q.V.M. Reg. No. 1973/5/104; (*b*) *Ls* 96, *Lt* 109, off Prime Seal Island, Furneaux Group, Bass Strait, 24 August 1973, Q.V.M. Reg. No. 1974/5/38. First Tasmanian record: the species had previously been reported, according to the Handbook (Munro 1957c), only from New South Wales; Marshall (1964) added Queensland.

Meristic characters. In this section and the next the datum for (*a*) precedes that for (*b*); entries in parentheses are measurements, mm, entries for proportions in square brackets are values by Waite (1899) for a specimen 210 mm in total length, and those given by McCulloch (1929), based on two specimens, 190, 200 mm.

D. 78, 79 [75, 75-87]. A. 58, 68 [67, 67-74]. V. 4/4, 4/4 [4, 4]. P. 6, 6/5, 5 [—, —]. C. 16, 16 [17, 15-16]. L. lat with 89 pores in main segment between operculum and hypural joint, 24 in supratemporal segment, 4 tubules and 20 small verrucae on caudal, 94+23+18 [102+19+18, 92-96]. L. tr: 26/1/35, 25/1/34 [—, 27/1/36].

Dimensions and proportions. Head (24.0, 19.2 mm), 5.5, 5.0 [6.6, 'about 6'] in *Ls* (131, 96); or 6.2, 5.7 in *Lt* (149, 109). Depth at front of eyes (17.6, 14.5) 7.4, 6.6, at back of eyes (29.3, 18.2) 4.5, 5.3, at operculum (44.0, 28.0) 3.0, 3.4; maximum depth, occurring a little behind, about at, one third of standard length (53.0, 34.0) 2.5, 2.8 [2.54, 2.5]; chord of arc of base of caudal rays (9.5, 6.2) 13.8, 15.5 in *Ls*.

Upper eye, eyeball only (see Norman 1934, p. 50) (5.1, 3.7) 4.7, 5.2 [eye 5.1 'eye about 4'], including soft orbit (5.9, 4.0) 4.0, 4.8; lower eye (5.0, 3.3), 4.8, 5.8 and (6.1, 4.2) 3.9, 4.6; interorbital, between eyeballs (2.4, 2.3) 10.0, 8.3 [interorbital 1.5 in eye; giving about 6 in head, —], between inner edges of orbits (1.8, 0.5) 13.3, 38.4, the soft fleshy orbital rims highly tumid in (*b*); snout to level of front eyeball (4.6, 4.9) 5.2, 4.3; shortest distance (callipers) between upper eyeball and dorsal profile (3.0, 2.1) 8.0, 9.1; shortest distance (callipers) between lower eyeball and ventral profile (5.7, 3.5) 4.2, 5.5; interval between middles of outer borders of upper and lower eyeballs (8.4, 7.0) 2.9, 2.7; distance between middles of inferior borders of upper lids (*i.e.*, direct shortest interval between pupils) (6.0, 4.5) 4.0, 4.3; length of maxilla (6.4, 5.0) 3.8, 3.8; length of lower jaw (9.4, 7.0) 2.6, 2.7 in head.

First dorsal ray (2.0, 2.0) 12.0, 9.6, ray at middle of fin (12.1, 9.1) 2.0, 2.1, last ray (12.0, 11.6) 2.0, 1.7 [—, posterior ray 1.5]; first anal ray (5.1, 4.1) 4.7, 4.7, ray at middle of fin (12.0, 9.0) 2.0, 2.1, last ray (13.3, 12.0) 1.8, 1.6 [—, posterior ray 1.5]; median caudal ray (18.0, 13.0) 1.3, 1.5; longest, 3rd, 3rd [—, 2nd] ventral ray of ocular side (8.2, 7.2) 2.9, 27 [—, 3.2], base of that fin (9.8, 5.3) 5.0, 5.6; longest, 3rd, 3rd ventral ray of blind side (7.8, 6.0) 3.1, 3.2, base of that fin (5.1, 3.7) 4.7, 5.2; length of pectoral of ocular side, without filamentous terminal appendage to one ray in (*b*) (2.9, 2.1) 8.3, 9.1, transverse extent of that fin (3.7, 2.9) 6.5, 6.6; length of pectoral of blind side (2.9, 1.9) 8.3, 10.1, transverse extent of that fin (3.5, 2.9) 7.0, 6.6 in head.

Remarks. The original description by Macleay (1882, p. 14), based on an example five inches in length, is brief: the only quantitative items are D+C+A 148, height about twice and a half in total length, eyes about their vertical diameter apart, ventrals about equal in size. Pectorals are mistakenly stated not to be present (the fins can readily be overlooked, not only because they are small, but also because they are partly overlain, and largely hidden from view, by the gill cover). More extended accounts, each accompanied by a figure, have been given by Waite (1899, p. 126, pl. XXXI) and McCulloch (1916, p. 61, pl. VIII, fig. 2).

Our specimens have been compared with these descriptions and illustrations. As may be seen from the data set out above, they exhibit, in general, reasonably good agreement with the quantitative items in them. Attention may be called, however, to the unexpectedly low anal count in (*a*), namely, 58, as against 68 in (*b*) and a reported range of 67-74 [this variation exceeds that noted for any member of the family diagnosed in the Handbook, the greatest discrepancy being 10 on 65 in *Aesopia microcephalus* (Gunther 1862)]. This feature inevitably raised a question as to whether two species were perhaps involved. However, apart from this point, and the presence of somewhat better developed pectorals in this fish as compared with (*b*) (see remarks on generic status, below), no significant difference could be observed between the two; while, on the positive side, they exhibit very close agreement morphologically, even in respect of quite minor features.

Some additional observations follow. Upper eye slightly in advance of lower.

Mouth to below 0.2, 0.3 of lower eye; twisted to blind side. Dorsal and ventral surfaces of head and much of opercular region on blind side with numerous small cirri; opercular border fringed. Dorsal and anal rays in front half, or so, of fin with white processes, on front rays extending along most of their length, successively decreasing in number backward to a single process. Lateral lines similar on right and left sides, but supratemporal branch less conspicuous on blind side. Scales ctenoid on both sides; extending on to dorsal and anal rays on both sides, rather more extensively on dorsal. Tube of anterior nostril on ocular side extending beyond orbital border of lower eye. Ventrals subequal, their bases contiguous, enclosed at their origin in a short common cutaneous sac, and the two anterior rays joined by a common membrane investing their proximal one-fourth or one-fifth; fins otherwise wholly separate from one another; no attachment to anal. In McCulloch's figure free margin of caudal extends but little beyond curve formed by continuation of borders of dorsal and anal, and is broadly rounded; in Waite's figure the caudal (while still fully confluent with dorsal and anal) has more the appearance of a separate structure, and is bluntly pointed; in both our examples the second condition obtains. On the other hand, in color pattern the fin here agrees more closely in both cases with McCulloch's figure, in which a submarginal black band is briefly bordered externally with white, whereas Waite's figure depicts a terminal black band: in our fish the dark portion is brown, not black.

General color of ocular side of (*a*) very dark brownish (warm mid-brown where scales are missing) of (*b*) light brown (fawn where scales are missing); of blind side whitish (where scales are missing, yellowish flesh, pale flesh). About a score of darker cross bars (somewhat indistinct, or faded out, in posterior one-third of fish), of which 5 (including an imperfect one before eyes) are on head; bars a little narrower than their interspaces anteriorly, subequal to them at middle of length: only obscure and faint indications of a continuation of them on to fins (*cf.* McCulloch's figure, contrast Waite's). Dorsal and anal are depicted in Waite's plate as for the most part evenly colored, with a white border, while McCulloch's figure — reproduced in the Handbook (Munro 1957c, fig. 494) — shows about half fin height occupied by a darker medial band: specimen (*a*) exhibits the second condition (band approaching black), (*b*) the first. Pectoral of right side more or less concolorous with trunk nearby, that of left side white or whitish. Right ventral mostly dusky olivaceous, first ray lighter; left whitish. Lips on ocular side and cirri on head flesh colored, lips on blind side white.

Generic status. *Zebrias* Jordan & Snyder, 1901 was separated from *Brachirus* Swainson, 1839 (equated, if Swainson's name is considered invalid, with *Synaptura* Cantor, 1849) to accomodate certain species (orthotype, *Solea zebrina* Temminck & Schlegel) in which the pectoral, instead of exhibiting well-developed rays arising from a short base, the fin being free of the branchiostegal membrane, has more or less rudimentary rays arising from a broad base, the fin being connected by a folded membrane to the upper part of the branchiostegal membrane, resulting in the formation of a funnel-like access to the branchial cavity. *Zebrias* is recognised in the Handbook, but is included in *Brachirus* by Norman (1926, p. 292) and in (the equivalent) *Synaptura* by Weber & de Beaufort (1929, p. 167). The latter justify their rejection of *Zebrias* by noting 'in some species a transistory arrangement between these extremes exists (e.g. *S. panoides* and *zebra*) in which the base of the pectoral is broader than usual, the upper rays are well developed and where a slight connection exists with the base of the pectoral and the branchiostegal membrane.'

Our two examples throw an interesting sidelight on the matter. In all four pectorals the base is broad, and there is some connection with the branchiostegal membrane. However, the extent and character of the resultant structure show considerable variation, being much less funnel-like in (*b*) than in (*a*). Further, while in (*b*) both fins have the form of a visually undifferentiated membranous lamina, from the evenly curved free border of which project several flexible pointed processes, representing tips of rays, in (*a*) the left has typical bayonet-like rays, clearly traceable throughout their length, and the membrane between them is strongly scalloped, the right fin

being much similar, but having the rays somewhat less fully developed. The existence in our fish of a direct connection between pectoral fin and branchiostegal membrane is here accepted as a convenient ground for referring them to *Zebrias*.

Family BRACHIONICHTHYIDAE

The three species reported from Tasmania — *Brachionichthys hirsutus* (Lacépède, 1804), *Brachionichthys politus* (Richardson, 1849), *Sympterichthys laevis* (Lacépède, 1804), all of which have this State as type locality — have been keyed (along with the South Australian *Sympterichthys verrucosus* McCulloch & Waite, 1918) in Part VI (1953,p. 158), and an account, with figure, given of a specimen of the first-named species from the Derwent estuary. The taxonomic status of these three nominal forms remains unresolved: it seems not improbable, however, that only one or at most two species occur here.

Genus *BRACHIONICHTHYS* Bleeker, 1885

Brachionichthys Bleeker, 1885, *Verh. Akad, Amsterdam*, 2, p. 112. Logotype, *B. politus* Bleeker [= *Chironectes politus* Richardson].

Brachionichthys hirsutus (Lacépède, 1804)

Lophius hirsutus Lacépède, 1804, *Ann. Mus. D'Hist. Nat.*, 4, pp. 202 and 210, pl. LV, fig. 3. Type locality: New Holland (Baudin) [= Tasmania, *fide* McCulloch (1929,p. 409)].

Chironectes punctatus Cuvier, 1817, *Mem. Mus. d'Hist. Nat. Paris*, 3, p. 434, pl. XVIII, figs. 2, 5 (skeleton). Based on *Lophius hirsutus* Lacépède (Péron) [Tasmania].

Distribution. Though recorded from New South Wales, and quite commonly taken in the Derwent, southern Tasmania, this species has very seldom been noticed from our northern coast, and has hitherto been unrepresented by other than southern material in the Queen Victoria Museum's collections. It is not clear whether this is due to scarcity of the fish or to non-use of suitable collecting techniques. Some observations are here made on two specimens, (*a*) *Ls* 90.2, *Lt* 118.0, (*b*) *Ls* 93.1, *Lt* 123.2, dredged off Cape Portland, at the north-eastern corner of Tasmania, on 8 September 1974 by Mr J. Shea. Data for (*a*) are given first.

Meristic characters. D.III, 18; III, 18. A.9; 10. P.7; 7. V.4; 4. C.9(1+6+2); 8(1+5+2). The presence in (*b*) of only 8 caudal rays is quite exceptional.

General body form. Head: trunk: tail = 28.3, 31.2: 21.6, 19.1: 50.1, 49.7. In terms of the set of variable factors of body-form proposed by Gregory (1928), these fish are specifiable as mesosomatic, gasterion preapical, apex median, gasterion anterior, mesonotic, mesogastric, nomopygidial, opisthion preuranic.

Chief dimensions as *Tls*. Length to termination of first dorsal 215, 242; base from spine I (illicium-bearing) to end of membrane 233, 267, from spine II 200, 237 (both measurements, callipers). Length (chord) of dorsal spine I 165, 140; spine II (chord) 231, 274; 1st ray 164, 242; longest (3rd, 3rd) ray 200, 322; last ray 80, 145. Length to origin, termination of second dorsal 310, 304; 863, 884; of anal 565, 559; 887, 892. Length of 1st anal ray 145, 153; longest (7th, 7th) ray 150, 195; last ray 100, 150. Length to pectoral origin (felt-for) 232, 272, to middle of axillary membrane 397, 430; length of fin from felt-for origin to 'elbow' 265, 301, from 'elbow' to tip of longest ray 259, 275; longest (3rd, 4th) ray 200, 226. Length to ventral origin 166, 177; length of fin 234, 236; longest (3rd, 4th) ray 183, 215. Length to vent 499, 503. Head to end of felt-for operculum 283, 311, length to gill opening (anterior base of tube) 382, 419. Snout 74, 75; eye 68, 73; interorbital 76, 83; maxilla 100, 122. Depth at front of eyes 177, 183, back of eyes 216, 210, operculum 222, 274, gill open-

ing 211, 215, vent 200, 193; maximum depth of trunk (= that of head) 222, 274; depth of caudal peduncle 77, 75.

Other features. Jaws subequal. Maxilla to below front of eye. Illicium lanceolate, compactly pleated; its spine smooth, flexible. Teeth, mucigerous system, spinules and scales as previously described (1953).

Coloration. General color greyish or buff. Head, body, trunk profusely marked with dark reddish brown spots, frequently tending to form regular lines, but seldom coalescing to constitute short bars. A light roundish area below interdorsal, more clearly developed in (*b*) and with dark centre on left side of that individual; a light spot above gill opening, another above anal origin, latter barely defined in (*a*). First dorsal spotted moderately in (*a*), heavily in (*b*). Second dorsal in (*a*) with very few spots in basal ½-4/5, numerous small spots along free border, in (*b*) whitish basally, white area round base of first ray, several other small whitish areas, remainder rather heavily spotted. Anal white, immaculate in (*a*), with 4 small dark spots in hind half in (*b*). Pectoral dark-spotted lightly in (*a*), heavily in (*b*). Ventral with about a score of spots in (*b*), half as many in (*a*). Caudal of (*a*) well spotted in distal, barely in proximal, half; of (*b*) proximal one-fourth immaculate, rest heavily spotted, particularly so distally.

Family ALUTERIDAE

Part IX (1960, p. 96) provided a provisional key to the local members of the family, taking note of 16 species, some probably nominal, reported from Tasmania to that time: included in the key was *Navodon setosus* (Waite, 1899), the first record for this State being made in that contribution. Species since added to our list are *Navodon multiradiatus* (Gunther, 1870), *Brachaluteres wolfei* Scott, 1969, the former in Part XX (1974b) of this series, the latter in a separate paper (Scott 1969). *Navodon degeni* (Regan, 1902) is here reported.

Genus *NAVODON* Whitley, 1939

Navodon Whitley, 1939, *Aust. Zool.*, 6(2), p. 179. Orthotype, *Balistes australis* Donovan.

Navodon degeni (Regan, 1902)

Pseudomonacanthus degeni Regan, 1902, *Proc. Zool. Soc. Lond.*, 2(2), p. 299, pl. XXIV, fig. 1. Type locality, Melbourne Market.

Cantherhines degeni McCulloch, 1929, *Aust. Mus. Mem.*, 5(3), p. 419.

Navodon degeni Fraser-Brunner, 1941, *Ann. Mag. Nat. Hist.* (ser. 11), 8(45), p. 185.

Nelusetta degeni Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p. 59.

Tasmanian record. This species, originally reported from Victoria, appears not hitherto to have been met with elsewhere. A Tasmanian example, *Ls* 210, *Lt* 250, was collected by Mr C.R. Steel at Wynyard on 15 November 1973; Q.V.M. Reg. No. 1973/5/117.

Fin counts. D.I,34. A.33. P.13/13. C.11 (1+9+1).

Principal dimensions. Values as *TLs* are followed in parentheses by measurements in mm. Length to origin of first dorsal 333 (70), termination 398 (83.5); of second dorsal 586 (123), 883 (185.5); of anal 581 (122), 893 (187.5). Length of dorsal spine 85 (17.8). Length to pectoral origin 314 (66), length of fin 138 (29), oblique width of base 50 (10.5). Length to pelvic spine 476 (100), length of spine 14 (3). Length to vent (middle) 550 (115.5). Head to origin of gill opening 295 (62), end of opening 324 (68), length of opening between parallels 29 (6.0), oblique length 60 (12.5).

Snout 271 (57), eye 62 (13), interorbital 81 (17). Length of mouth cleft 21 (4.5), width 52 (11). Shortest distance (callipers) from upper end of gill opening to eye 49 (10.3), from eye to base of dorsal spine 50 (10.5). Depth at front of eyes 290 (61), at middle of gill opening 321 (67), at back of eyes 329 (69), at vent 329 (69); maximum depth with pelvic flap 390 (82), without flap 348 (73); depth of caudal peduncle at anal termination 102 (21.5), minimum 88 (18.5). Widths at the same four points 119 (25), 129 (27), 129 (27), 119 (25); maximum width of head 129 (27), of body 133 (28); width of caudal peduncle at anal termination 48 (10), at hypural joint 33 (7).

Comparative proportions. Though clearly conspecific with Regan's Victorian type, *Lt* 190 (with which it agrees in meristic characters, though a second dorsal spine, noted by Regan as 'scarcely visible', was not detected), the present, somewhat larger, specimen exhibits some interesting variations in proportion as follows (holotype datum first). Depth of body equal to length of head (with pelvic flap 1.2, without flap 1.1, head). Snout 3 2/3 (4.4) eye diameter, which is equal to (0.8) interorbital. Length of gill opening about 2/3 (oblique length 1.0, horizontal extension 0.5) eye. Length of dorsal spine 2 2/5 (3.8) in head. Pectoral almost as long as (1.6) dorsal spine. Longest, 8th or 9th dorsal and anal rays (8th, 8th) equal to half head (dorsal 0.51 head, anal 0.49).

General features. Regan's description of the holotype is a rather brief one; a more detailed account, based on the present example, is here offered.

Head (taken throughout as length to end of gill opening), trunk, tail in ratio 32.4: 22.6: 45.0. Specification of body form (system of Gregory 1928) hypsisomatic, gasterion preapical, apex median, gasterion median, mesonotic, mesogastric, leptopygidial, opisthion preuranic.

General form rather elongate, subelliptical, anterior end more rounded than posterior. Dorsal profile back to highest point, in interdorsal, tolerably evenly convex, a trifle flattened in middle portion of snout; convexity decreasing caudad, lapsing to become briefly concave on peduncle. Ventral profile in advance of vent convex overall, pelvic flap contributing little extra, but with long shallow median concavity; behind vent subequal to dorsal profile here. Greatest depth 2.6 in *Ls*, 1.2 head. Caudal peduncle stout, its length 1.2 its least depth, 3.0 in head.

Anal originating barely in advance of dorsal, at 0.58 *Ls*, ending barely behind dorsal, at 0.89 *Ls*, its base 1.05 dorsal base, or just less than head. Regan states dorsal and anal rays after reaching 8th or 9th decrease to about 20th, rest being subequal (though his figure seems to show last anal ray longer than some shortly preceding it). In our fish anal rays increase rapidly, in a convex curve, to 8th, which is half head, thereafter decreasing, in a bold convex curve, most rapid up to about level of middle of base, consistently up to last, 33rd, ray, which is 1.4 in 1st, 1.8 in 20th, 4.7 in 8th. Profile of soft dorsal broadly similar to that of anal, but in neighborhood of 20th ray several rays subequal, with one, 20th (13.0 mm) slightly longer than immediately preceding ray (12.2); longest ray 1.1 longest anal ray. Dorsal spine inserted above posterior border of orbit, wholly behind level of gill opening; length to base exactly one-third *Ls*; short, 3.8 (*cf.* Regan, 2.4) in head; anterior border almost straight for three-quarters of its length, then curving in slightly to end at moderately acute point; posterior border straight for nine-tenths of its length, the curvature of the spine-end being provided mainly by anterior border; anterior surface well rounded, wholly covered with very numerous closely-set minute granulations, mostly rounded, some quite bluntly pointed, no spinules present, except three, very small, on right anterior border near middle one-third of length; posterior surface smooth, save for a few granulations from anterior surface just extending round edge, a dark, low mesial ridge, traceable from within 2-3 mm of tip down to about 1 mm above origin of fin membrane, located at two-thirds height of spine. First dorsal membrane small, low, oblique height about one-sixth eye, extending, mostly as closely

adherent slip, along about two-thirds of groove housing spine when depressed, this groove extending for full length of spine, deepest and widest in anterior two-thirds, greatest depth about one-fourth eye. Pectoral originating at 0.3 *Ls*, extending 0.6 of distance towards vent, broad, rounded, longest in upper half, all rays simple, beset, most abundantly proximally, with minute granulations, extending up ray for from about one-tenth to one-fifth of its length. Pelvic spine small, length less than one-fourth eye; blunt process, minutely rugose, about a dozen larger, still quite small, mammilloid elevations round margin and near tip. Pelvic shield traceable forward to below anterior one-ninth of snout. Pectoral broad, rounded, longest in upper half, length to origin 0.31 *Ls*, extending 0.59 of distance towards vent, all rays simple, beset, most abundantly proximally, with minute granulations, extending up ray for from about one-tenth to one-fifth of its length. Caudal moderate, length from hypural joint 1.7, length of median ray 2.0 in head, distal margin markedly and symmetrically sinuous, a central convexity extending behind level of a concavity on either side of it by half an eye diameter; 1st, 11th rays undivided, 2nd, 10th with 4 rami, 3rd, 9th with 8, rest normally with 16 (an occasional failure in final division), rays beset, most abundantly proximally, with minute granulations, extending maximally up ray for three-fourths of its length.

Eye moderate, about equidistant from base of dorsal spine and upper end of gill opening, that distance four-fifths of its diameter; length to orbit 1.2 in head. Mouth small, its antero-posterior extension (including lips) about half its width, the latter one-sixth length of head. In upper jaw two large subtriangular median teeth, contiguous in their distal half (most of exposed portion); flanked on either side by two much smaller, well-separated, less acute teeth, base of inner one on right contiguous with, that on left distinct from, base of large tooth; a soft lobe, resembling a tooth, just external to outer tooth on each side. In lower jaw two distally apposed large teeth like those of upper jaw; outer edge of each continuous with a low ridge-like cutting edge, on right side linear, on left somewhat sinuous; an odontiform process, on right side subtriangular, on left subconical, rising from middle one-fifth of ridge. Gill opening with lower end on line joining mouth cleft and middle of caudal peduncle; wholly beneath eye, lower end behind anterior orbital border by 0.4 eye, upper end in advance of posterior orbital border by 0.15 eye ('below hind margin of eye', Regan); its oblique length just less than eye diameter. General feel velvety; scales small, closely set, with 6-12 knobs or blunt spinules in an arc along hind border; varying in size by a factor of 2 or more, coarser on lips and nearby. Very small scales extend all over low, but well-developed, sharply delimited basal sheath of soft dorsal and less extensive anal sheath.

Coloration. Ground color fairly uniform somewhat yellowish grey; more dusky, less yellowish on most of snout above a line from mouth to gill opening, with continuation back under dorsal spine, also in small area behind and below pectoral; basal sheaths of soft dorsal and anal brownish olivaceous; lips, chin, throat light, or very light, grey; teeth hyaline or faintly yellow. The diagnosis of the body-form, according to the system of Gregory (1928) is hypsisomatic, gasterion preapical, apex median, gasterion median, hypsinotic, bathygastric, leptopygidial, opisthion preuranic.

Pattern comprises long dark stripe near hinder part of dorsal profile, breaking up anteriorly into one or two short bars and spots, and on head, trunk, tail many dark spots, usually conspicuous and well-rounded, sometimes, especially on snout, less intense, less clearly delimited, much more numerous than in the holotype as figured (Regan 1902, pl. XXIV, fig. 1); pattern differing in detail on the two sides. On left side pronounced dark bar originating at second one-third of interdorsal, running back, without noticeable alteration in width, to meet a subvertical bar on upper half of caudal peduncle at hypural, its course more or less following curve of body, but gradually approaching profile caudad, its maximum distance from it about twice its own width or about half eye; its course continued forward by a short stripe, subequal to eye, and an arc of 7 spots, decreasing in size and intensity forwards, most anterior

in advance of eye by half eye diameter: spots on snout 30-40, more or less confined to upper half, the anterior ones very faint, mainly disposed in 6-7 lines radiating forward and downward from eye: on trunk and tail a row of 14, evenly spaced, and, except for one above anal termination, in a continuous curve, more or less following ventral profile from anal origin to last one-fourth of caudal peduncle, distant anteriorly from profile by about an eye diameter, posteriorly by half as much; short row of 13 between main row and anal base above hind half of latter; 18 on lower one-third of flank between head and vent, fairly closely, somewhat irregularly, set, 7 continuing in the general sense of the line of 14; about 25 others, mostly irregularly disposed, but 5, larger than the rest, largest about half eye diameter, or twice modal size, above and behind posterior part of anal base, in 2 pairs, followed by 1 on middle of caudal peduncle. Chief difference exhibited by right side: dark stripe below dorsal profile extending unbroken somewhat further forward to below end of spine-groove, followed by short stripe below groove and some indeterminate spots; 22 spots in a more or less continuous series from near end of caudal peduncle, above ventral profile to below level of middle of pectoral, surmounted by just separate arc of 3 closely below pectoral; rest disposed overall in much the same way as on left, with some individual variation, including occurrence of 2 on middle of flank about above vent, not present on left.

Dorsal spine in general greenish brown, median ridge on posterior surface dark brownish; exposed membrane greenish brown except lower half of distal border, which is blackish; inside greenish amber spine-groove closely adherent strip of membrane brown. Dorsal and anal rays bright blue, their extreme, somewhat spatulate, tips whitish; dorsal membrane virtually hyaline, anal very pale yellowish. Pectoral rays bright green, septa white, tips white or hyaline; membrane colorless. Uppermost and lowermost caudal rays colorless, rest chiefly bright blue, proximal one-sixth or so obscurely greenish, tips very light bluish or whitish; membrane hyaline.

Remarks. The most noteworthy differences exhibited by our specimen when compared with the holotype include rather shorter snout (4.4, *cf.* 3 2/3, in head), much shorter dorsal spine (3.8, *cf.* 2 2/5, in head), decidedly more extensive pattern of spots, simpler, and differently tinted, color pattern in caudal fin. These would seem to represent individual variations only.

Fin patterns. Neither the dorsal nor the anal rays are completely specifiable by two or three sets of length-number equations, the middle region of both presenting no simple recognizable pattern (though partly specifiable in terms of several subsets each with few members): equations can be formulated, however, for the first 8 rays of each fin, the last 10 of the dorsal and the last 8 of the anal. It is of interest to observe that, while in the majority of species examined earlier, and in all those dealt with elsewhere in this paper, the length-number relation is of the form $L = bN^k$ [with N^1, a serial number counting cephalad, or otherwise conventionally in reverse sequence, commonly substituted for N in descending series], yielding a linear plotting when expressed as $\log L = k \log N + \log b$, the appropriate equation for (specifiable) dorsal and anal rays in the present fish is $L = k \log N + c$, and that for pectoral rays is $\log N = kN + c$.

For dorsal rays 1-8 $L = 30.072 \log N + 7.4627$: measured (in parentheses, predicted) lengths, mm, 8.0 (7.5), 15.2 (16.5), 22.0 (21.8), 26.2 (25.6), 28.8 (28.5), 30.9 (31.0), 32.3 (32.9), 34.8 (34.6); $t = 36.654$. For rays 25-34 $L = 4.4121 \log N^1 + 6.5157$: 6.5 (6.5), 8.0 (7.8), 8.6 (8.5), 8.9 (9.1), 9.4 (9.6), 10.0 (9.9), 10.0 (10.2), 10.5 (10.5), 11.0 (10.7), 11.2 (10.9); $t = 10.560$.

For anal rays 1-8 $L = 25.879 \log N + 10.3141$: 10.2 (10.3), 18.0 (18.1), 23.2 (22.7), 26.9 (25.9), 29.2 (28.4), 30.5 (30.5), 32.0 (32.1), 33.3 (33.6); $t = 37.889$. For rays 26-33 $L = 3.7306 \log N^1 + 7.0273$: 7.1 (7.0), 8.4 (8.2), 8.7 (8.8), 8.9 (9.3), 9.2 (9.6), 10.0 (9.9), 10.5 (10.2), 10.6 (10.4); $t = 9.668$.

In the pectoral measured lengths (right fin) of the 2 members of the first subset are 23.0, 24.0. For the remaining rays, 3-13, log L = –0.3413 N + 1.4220: 23.9 (24.4), 22.4 (22.6), 21.0 (20.9), 19.5 (19.5), 18.0 (17.8), 16.8 (16.5), 15.4 (15.2), 14.0 (14.1), 13.1 (13.0), 11.9 (12.0), 11.0 (11.1); t = 62.156.

Pectoral patterns in other species. The occurrence in *Navodon degeni* of an arithlog number-length pattern, not previously encountered in a pectoral fin, has prompted a preliminary examination of the position obtaining in the pectoral of some other members of the genus. In 3 examples of *Navodon australis* (Donovan, 1824), (*a*) *Ls* 167, *Lt* 204, (*b*) 186, 220, (*c*) 191, 225, it has been found all pectoral rays can be treated as 3 subsets, each specified by an equation of the form log $L = kN + c$; further, in these specimens the subsets exhibit intersection, giving a continuous formulation for the whole fin. Similar subsets were recognized in an example of *N. multiradiatus* (Gunther, 1870), *Ls* 260, *Lt* 330, and in an example of *N. hippocrepis* (Quoy and Gaimard 1824), *Ls* 279, *Lt* 328; the second and third sets only intersecting in the former species. The relevant data are summarized below; but the subject calls for further and wider investigation.

For specimens (*a*), (*b*), (*c*) of *N. australis* the members of the first subset are rays 1-4, 1-4, 1-3; of the second subset 4-8, 4-9, 3-10; of the third subset 8-14, 9-14, 10-14, respectively. For the first subset the coefficients of N are 0.01931, 0.01794, 0.02753; for the second subset - 0.01416, - 0.02739, - 0.04596; for the third subset - 0.03281, - 0.03921, - 0.01952. The corresponding independent terms are 1.2154, 1.2207, 1.2430; 1.2982, 1.3173, 1.3437; 1.2537, 1.1958, 1.2369. Values of t are 9.394, 11.157, 24.139; 11.915, 43.327, 17.287; 30.900, 10.962, 23.214. For *N. multiradiatus*, with subsets of rays 1-3, 4-8, 8-14, the coefficients of N are - 0.02174, - 0.01781, - 0.4182; the independent terms 1.3364, 1.4152, 1.3687; t = 69.054, 14.264, 29.631. For *N. hippocrepis*, with subsets 1-4, 4-7, 7-13 the coefficients of N are - 0.009403, - 0.01306, - 0.04343; the independent terms 1.3593, 1.4011, 1.3966; t = 5.065, 6.358, 78.641.

Fits for regression equations are (as indicated by high t values) very good. For 48 items for *N. australis* (*i.e.*, including double appearance of a ray) predicted lengths differ from measured lengths by 0.0-2.7, $\bar{x}$ 0.76 ± 0.11%; for 15 items for *N. multiradiatus* by 0.0-1.5, $\bar{x}$ 0.67 ± 0.14%; for 15 items for *N. hippocrepis* by 0.0-2.5, $\bar{x}$ 1.20 ± 0.17%.

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SOME NOTES ON THE ANTERIOR DORSAL FIN AND VENOUS DRAINAGE IN *CALLORHINCHUS* (HOLOCEPHALI)

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(with two text-figures and three plates)

SUMMARY

The region of the anterior dorsal fin of the elephant-fish *(Callorhinchus callorhynchus* (L.) has been examined by dissection, by injection of radio-opaque material and in serial sections. Particular attention has been paid to the venous system in the region.

A large venous sinus lies below the basal plate of the fin skeleton and has connections running anteriorly and posteriorly in the midline. Anteriorly, the sinus is connected with the left posterior cardinal vein by a large communicating vein which lies close against the left side of the vertebral column. This arrangement is generally similar to that found in the Selachii, but in the latter group two venae circulares are found instead of the median dorsal sinus of *Callorhinchus* and other Holocephali.

INTRODUCTION

The Holocephali are a small group of shark-like fishes, of which *Chimaera* is the principal representative in the northern hemisphere and *Callorhinchus* in the southern hemisphere. Hobson (1841) gave the first general description of the anatomy of *Callorhinchus*, and only some accounts of particular systems have appeared since (for a bibliography see Stahl 1967). The present notes report a preliminary study of some of the structures associated with the anterior dorsal fin of *Callorhinchus*, in particular the venous channels; and comment upon Hobson's findings.

MATERIAL AND METHODS

Our examination of the anatomy of *Callorhinchus* was limited by the small quantity of material available to us in London. Two small specimens of *C. callorhynchus* (L.) were generously made available to us by Mr. P.J. Whitehead of the British Museum (Natural History) and some others collected in the estuary of the Tamar River, northern Tasmania, were kindly sent to us by Mr. D.C. Wolfe of the fisheries section of the Tasmanian Department of Agriculture.

Nearly all our material was found to be preserved inadequately for histological study and only one series of serial sections of the region of the anterior dorsal fin was reliable. Radio-opaque fluid ('Chromopaque') was injected into the pulpy region at the base of the anterior dorsal fin to study the extent and connections of the venous sinuses in the region by X-ray photography. Several specimens were dissected to study gross morphology.

OBSERVATIONS

The massive anterior dorsal fin lies a short distance behind the head (text-figures 1 and 2). It is roughly triangular in shape and comprises little more than a double layer of skin supported by two layers of "dermal fin rays", and having a prominent and robust spine in its anterior margin. The spine is associated with a basal

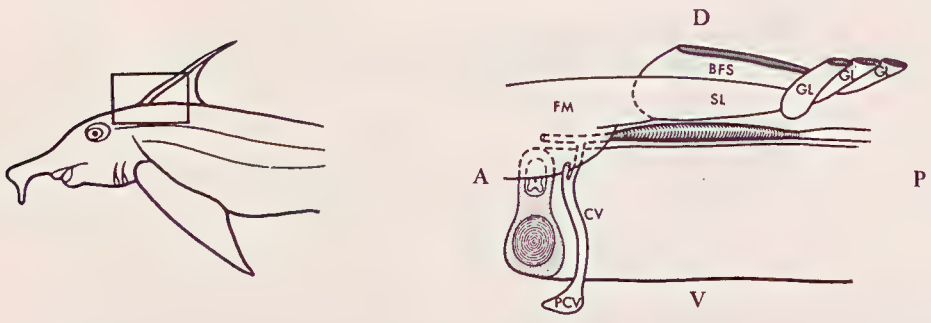

FIG. 1. - (a) Outline sketch of anterior end of *Callorhinchus callorhynchus*. The box indicates the region shown in (b).
(b) Three-dimensional diagram of region of the anterior dorsal fin, from the left side, to show the dorsal venous sinus lying below the basal fin skeleton, and communicating with the posterior cardinal vein.

A: anterior; P: posterior; D: dorsal; V: ventral; and other symbols as for text-figure 2.

skeletal element embedded in the midline between the axial muscles of the two sides. The basal element is connected to the skull and vertebral column by ligaments, and is acted upon by a system of muscles in such a way that the anterior spine (and therefore the fin) can be elevated and depressed. When the fin is depressed the blade folds fanwise, the mass appearing to be accommodated to some extent in a mid-dorsal groove because the tissues underlying the posterior part of the fin are spongy. Details of the structure of the fin skeleton and its musculature were not studied.

In front of the dorsal fin, the midline is occupied on each side by a bundle of muscle which extends from the back of the head to the basal plate of the fin skeleton. These bundles are separated from the axial musculature by an areolar partition, the separation becoming more and more distinct as they approach the basal plate, and they end in a fibrous sling common to the two sides which is attached to the keel of the plate posteriorly. Running longitudinally in the areolar partition is the large dorsal cutaneous vein. Just in front of the basal cartilage of the fin this vein gives off branches on each side which communicate with veins in the fascial partitions separating the bundles from the axial musculature. The two connecting vessels, which run alongside the vertebral arch, differ markedly: that on the left side is large while that on the right is small. Moreover, the left hand vessel continues ventrally beside the basal part of the arch and the body of the vertebra to connect with the left posterior cardinal vein, but on the right side there is no corresponding connection, or at most a very tenuous connection with the right posterior cardinal vein (plate 1). This connecting vessel is known as the profunda vein. Immediately behind it the dorsal cutaneous vein becomes much larger, forming a wide vascular pad separating the fin skeleton and its associated musculature from the vertebral column and the adjacent part of the axial musculature; it may now be called the dorsal fin sinus (Stahl 1967). The areolar tissue separating the dorsal fin and its associated structures from the surrounding tissues changes at this point, now containing many blood vessels and being very loose, so much so that the serial sections show many tears (and artificial spaces) along the fibrous planes.

X-ray studies have shown that when radio-opaque fluid was injected into the areolar tissue at the base of the dorsal fin, it flowed into vessels in the abdomen

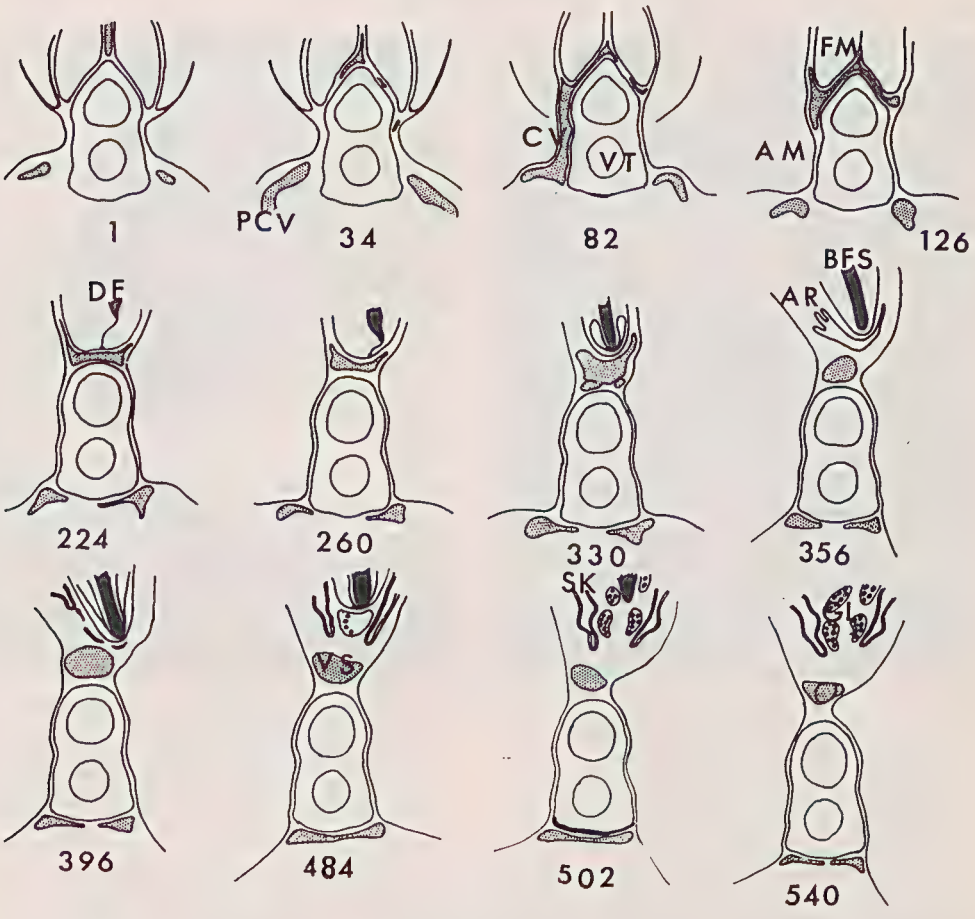

FIG. 2. - Outline sketches of the region of the vertebral column and the base of the anterior dorsal fin to show the relationships of the dorsal venous sinus to the fin, and the venous connection between the anterior end of the sinus and the left posterior cardinal vein, based upon serial sections of a specimen 27 cm long from tip of snout to end of tail.

The sketches carry numbers of the serial sections to which they correspond, the number "1" being given to the first section drawn.

Abbreviations -

AM axial musculature
AR areolar tissue separating dorsal fin from axial structure
BFS basal fin skeleton
CV communicating vein (profunda vein)
DF dorsal fin
FM anterior fin musculature
GL "glands" of origin of ceratotrichia
PCV posterior cardinal vein
SK skin
SL attachment of anterior fin muscles to basal fin skeleton
VS dorsal venous sinus
VT vertebral column

along a connecting vessel, and that the dorsal fin sinus was co-extensive with the attachment of the anterior dorsal fin to the trunk.

PLATE 1. - Section 92 of series of text-figure 2; shows communicating vein on left side of vertebral column joining dorsal longitudinal vein to posterior cardinal vein; abbreviations as for text-figure 2.

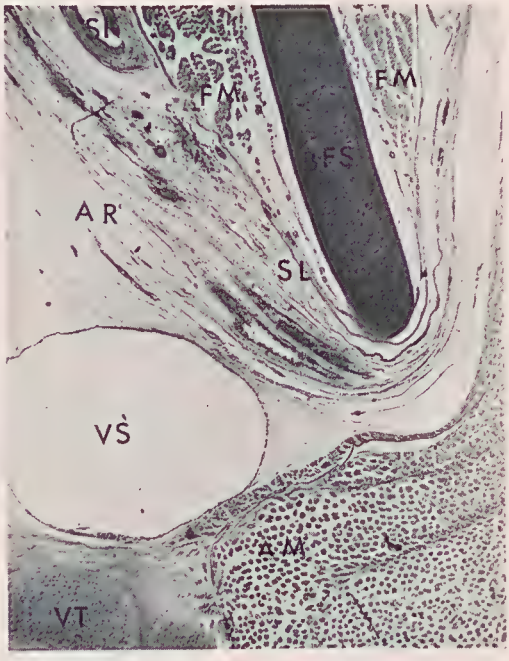

PLATE 2. - Section 396 of series of text-figure 2; shows relationships of dorsal venous sinus to vertebral column and to anterior dorsal fin in region of basal plate of fin skeleton; abbreviations as for text-figure 2.

The "dermal fin rays" of the anterior dorsal fin of *Callorhinchus* appear to take their origin in clusters of cells on each side of the basal plate. From these separate "glands" (plate 3) the ceratotrichia (Goodrich 1904) run upward, fanning out in the blade of the fin to form a closely set series of rays deep to the epidermis of each side.

Halstead and Bunker (1952) have found glandular tissue in the epidermis covering the anterior dorsal spine of the holocephalan *Hydrolagus colliei*, and they considered it to produce venom. Our *Callorhinchus* material was not sufficiently well preserved to make accurate observations on this point, but we have located a strip of vacuolated cells lying on each side of the origin of the thin double layer of epidermis connecting the dorsal spine to the blade of the fin, in the posterior interdentate region of the spine. The apices of these cells are directed to a shallow groove alongside the attachment of the double layer. These lines of epithelial cells seem to correspond in position and structure to those reported in *Chimaera* by Evans (1923). Whether the secretion of these cells contains venom or not requires further investigation; and the question must be asked, what is the biological function of such venom? There appear to be no records of any injuries having been received by man from *Callorhinchus* in Tasmania.

DISCUSSION

In both Selachii and Holocephali, cutaneous venous drainage takes place along

lateral cutaneous veins supplemented by dorsal and ventral cutaneous vessels. However, there is a structural difference between the two groups in regard to the dorsal cutaneous vein: in the Selachii this vein divides into venae circulares running on each side of the dorsal fin (Birch *et al.* 1969; Daniel 1934; Marples 1936; Mayer 1888; Parker 1886), while in the Holocephali there is a median dorsal fin sinus (Hanson, quoted by Satchell 1971; Stahl 1967). In both groups a vessel connects the dorsal cutaneous vein in the region of the anterior dorsal fin with deep vessels in the roof of the abdominal cavity. This profunda vein is given off from the dorsal cutaneous vein either just cranial to the dorsal fin sinus (Holocephali), or where the venae circulares join at the caudal end of the anterior dorsal fin to re-form the dorsal cutaneous vein (Selachii). The profunda vein usually passes to the left of the vertebral column, but in *Heterodontus* (Birch *et al.* 1969) it may pass on either side. The particular deep vein with which the profunda vein communicates depends upon the position of the anterior dorsal fin along the body, so that in *Squatina* (Marples 1936), where this fin lies far caudally, the profunda vein communicates with the caudal vein.

Edmund Charles Hobson was one of a small group of naturalists in Australia at a time when local interest in science was beginning to develop. The only local scientific journal in which such workers could publish their results was the *Tasmanian Journal of Natural Science* (Plomley 1969), and as well as his paper on *Callorhinchus* Hobson published in it some observations on the blood of the platypus and a number of notes on the geology and palaeontology of south-eastern Australia.

Hobson's finding in *Callorhinchus* "a vascular structure which I consider to be an accessory organ of respiration", and a supposed "communication with the gullet", are clearly wrong, though he was correct in seeing a significance in the movements of elevation and depression of the anterior dorsal fin. Evidently he was led into error by being able to press bubbles of air from the mass of spongy areolar tissue beneath the base of the fin. Air would readily be trapped in these tissues during dissection, and later could be pressed from them, as has been found in the present investigation. The functional significance of Hobson's observations is to be found in the structure of the venous system in elasmobranch fishes. In such fishes most of the veins are sinusoidal in form, and the blood in them is at very low pressure (Satchell 1971). Mechanisms are therefore needed to return blood to the heart, and these are essentially the pressures exerted on the vessels by somatic (c.f. Mayer 1888) and visceral movements, with direction of flow controlled by valves. In the Holocephali the flow of blood in the dorsal cutaneous vein is likely to be aided by movements of the anterior dorsal fin, and because the dorsal fin sinus is associated with a mass of areolar tissue, pressures developed at the base of the fin would be transmitted efficiently to the sinus.

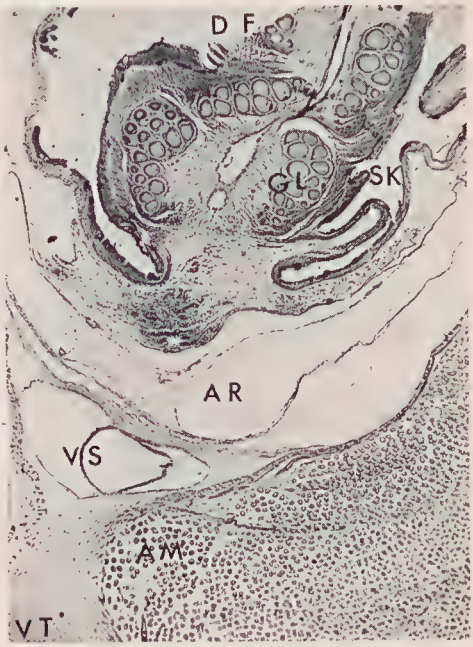

PLATE 3. - Section 536 of series of text-figure 2; shows relationships of dorsal venous sinus to vertebral column and to anterior dorsal fin in region behind basal plate of dorsal fin; abbreviations as for text-figure 2.

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